VOL·II NO·3

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

MARCH 1918

SOCIETY OF AUTOMOTIVE ENGINEERS INC
29 WEST 39TH STREET NEW YORK

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. II March, 1918 No. 3

The VALUE OF MEMBERSHIP IN THE SOCIETY

THREE links make up the chain we are forging to win the present conflict. Joined with the link representing the actual fighting forces are those of industry and agriculture. Each of these links must be strong to meet sudden shock and to endure unending fatigue. The final strength of the chain depends, however, on the human element involved—on the individuals making up the military, the industrial and agricultural organizations.

On each individual rests the task of serving in the way he can serve best. But the best work of the individual can be done only as a result of his loyal cooperation with his fellows, so that their strength bolsters his weakness, and his strong points help to make the united effort of the maximum value. On the one hand we have cooperation, on the other ruin.

Loyal cooperation must thus be the law among nations, and equally among groups, classes and individuals in each nation. It is as a result of this spirit of loyal cooperation that the members of the Society form the strongest *personal* group in the automotive industry. Other agencies perform valuable work in the industry, but the Society is recognized nationally, and internationally as well, as the exemplar of successful cooperative effort.

On the efforts of S. A. E. members, on their success as leaders of a professional group, rests the supply of devices and material without which the military forces must succumb; on them depends the organization and administration without which the industry must fail in its duties to the nation; and on them is based the production of machines without which food will not be produced in sufficient quantities, thus imperilling the very life of the people of this nation and of its Allies.

Accepting the fact that we must all pull together as a Society, then what can each individual member do, over and above his daily routine work?

Obviously, each member can support all endeavors of the Council, officers, committees, and of other members, to maintain the Society at its highest efficiency as an operating organization. The work the members of the Society are doing in designing and building automotive apparatus necessitates that the fullest measure of support should be accorded all its activities. What is it worth to the industry, to the nation, or to the Allied cause itself, to maintain the S. A. E. at its highest efficiency?

It certainly is worth the whole-hearted support of all members, not only in paying their dues—which is, of course, a worth-while indication of interest in the organization—but also in supporting the S. A. E. standardization program in all its phases, in promoting the free interchange of scientific knowledge by means of the preparation or discussion of technical papers at meetings of the Society, or of its sections; in attendance at the meetings, dinners, and other Society affairs, which act both to create the acquaintanceship and friendship without which men cannot work together effectively, and to enable the presentation of addresses that will serve at once as an inspiration and an education.

The Society activities are so broad that it is too much to expect that every member should be interested in every detail. But every member should bear in mind that his particular experience can be useful in some branch of the work. The different divisions of the Standards Committee, for instance, can attain their maximum usefulness only when the widest range of experience is brought to bear during the formulation of their reports. These reports are given in preliminary form in the monthly issues of THE JOURNAL of the Society, so that every member can make suggestions for their improvement, if he so desires. Every member may not be in a position to take part in committee work, but all members can aid the Council and committees of the Society by their advice and suggestions.

Still another, and perhaps the most important, way in which the members can help is to tell non-members about the work the Society is doing, and to invite such of them as are properly qualified to apply for membership.

The Society increased substantially 50 per cent in membership during the last calendar year, and during the present year it is hoped that the 1917 record will be broken. In fact, the belief that the work of the Society should command the support of 5000 members is so strong that the Council has already approved the recommendation of the Membership Committee that a determined effort should be made to add 2000 new members during the year. This increase is even larger, proportionally, than was made last year, and it will be obtainable only because of the cooperation of all the members.

The 2000 future members must be obtained from men who recognize the fact that membership is a duty they owe to their profession and to the industry, both of which have gained much by S. A. E. activities; they must also appreciate the work they can do for the Society and the benefits to be derived from association with its

members. Among the latter are the men in engineering, production and business branches of the companies building automotive apparatus and also of those supplying parts, materials, accessories, tools, gages, equipment; instructors and students in the universities and schools allied with the industry; transportation and maintenance experts; scientists and experimental workers—all through their connection with the Society accomplishing much that can be done by an engineering organization, with its aggregate of members, but which would be impossible for any of them as individuals.

Judging an Engineering Society

An engineering society can be judged in many ways: by the results of its past and present activities; by its plans for the future; by the benefits accruing as a result of membership, and from the activities of the individual members in Society affairs; by the standing and numerical strength of its members; and finally, by the estimation in which its members, the industry to which the society is allied, and the world at large, regard the organization. These judgments are of the utmost value both to the members, in order that they may have a true perspective in relation to their own society, and to those who logically should become applicants for membership. Let us, therefore, consider these points in the order in which they have been mentioned.

Activities in the Past.—These were mainly in the passenger-car and motor-truck fields, relating, therefore, to the work of the former Society of Automobile Engineers. The other automotive activities are of such recent date that they can better be considered as of the present.

Three outstanding achievements of the Society of Automobile Engineers can here be recorded. The first is the development of that cooperation, that mutual helpfulness, that willingness to interchange engineering information—in a word, of the S. A. E. *spirit*, a type of loyalty to the profession and industry that has resulted in large part in the creation of a new industry.

The American automobile industry has become full grown in less than a score of years. Yet the part of the S. A. E. in this growth has been noted for a moment and then taken for granted, forgetting many specific and far-reaching accomplishments have been due to the Society. Some day a history dealing with events in this country in the early part of the twentieth century will tell future generations of the effect the birth of the automobile industry had on social life in city and country, on the economic problems underlying road transportation, and on the military problems involved in defending the nation against the aggression of militarism. Then should the future historian give credit to the spirit underlying the S. A. E. for its work in creating all the great, tangible results that the Society has obtained.

Value of Standardization

The creation and the securing of the wide use of standards and recommended practices has been the most tangible result of the Society activities. The recognition that the main purpose of S. A. E. standardization is to improve the product, lessen its cost, and eliminate the unnecessary, all for the benefit of the whole industry, and without in any way limiting individual improvements in design, has brought about the widest adoption of S. A. E. standards and recommended practices; not through compulsion of any kind, but because of the intrinsic merit of the recommendations made by the Society. S. A. E. steels, carbureter flanges and fittings, seamless-steel tubings, lock washers, screw threads—these are but a few of the many standards in wide use as a result of the careful study of the basic problems made by the Society through its Standards Committee.

Technical Discussions

The third achievement of the Society is the advance in engineering practice resulting from the presentation, discussion and wide distribution of technical papers in large number and of profuse variety. These papers have heralded, and in fact have been largely responsible for the continuous advance made in the design and construction of automobiles. The willingness with which members doing important original work have given the results of their labors to other members, this applying both to those preparing and discussing technical papers, is a tribute to such members and to the Society whose spirit they have so worthily represented. It is impossible to estimate the value that the S. A. E. technical papers have had in encouraging inventors and engineers, who, although unable perhaps to hear the papers given, have kept in touch with the developments through their membership in the Society and the receipt of the Society publications containing reports of the proceedings.

Activities in the Present.—Almost two years ago the knowledge that a conflict with Germany was only a question of time led to the formation of the Society of Automotive Engineers. The policies found most successful after long trial by the Society of Automobile Engineers have naturally been adopted in the new organization, at least as far as possible under war conditions. The wide use of automotive apparatus in war has given the Society an immense task in providing from among its membership engineers both to carry on the immense Governmental automotive programs and at the same time to keep factories throughout the country running at the highest speed. The requirements for immediate standardization of aircraft, tractor and motorboat subjects has led to a concentration of that important part of the Society activities on what is practically work for the Nation.

The current technical papers also are evidence of the efforts the Society and its members are making for the common cause. The general advance in automotive engineering is of the utmost importance, hence regular meetings of the Society and of the sections are being held to discuss technical subjects, which are, as a rule, of the sort that will help the members, and through them the entire industry, to do better work for the nation. Papers read recently on the Liberty aviation engine, United States military motor trucks, standardized submarine chasers, for all of which members of the Society were largely responsible, are indicative of the present trend of Society affairs.

Plans for the Future.—In spite of the fact that the engineering requirements of the war are taking up practically all the time and energy of the members of the Society, considerations of wisdom dictate the looking ahead to the engineering situation after the war is over. It should be realized, of course, that the accelerated development of automotive apparatus due to the war will be of the greatest value after peace comes. The great advance made in the design and production of aircraft, of motor trucks, and other automotive apparatus, the standardized methods being applied to shipbuilding—these will have their effect when the factories of the automotive industries are again turned to production for the

uses of peace. It goes without saying that the standardization work of the Society must be continued now and after the war. The value of this has proved so great that its continuance can be taken only as a matter of course. But outside of the practically routine development involved in standardization must be a steady advance in engineering practice, so that the various types of automotive apparatus will be continually improved and made more efficient.

Investigation of the fuel problem must be carried on so that the future needs of the industry will be met. More efficient engines must be used; they must operate economically on our present fuel, or be designed to use an entirely different type of fuel. New thermal operating cycles must be tried out. The possibility of getting a better method for the transmission of power from the engine to the road wheels must be considered. The engineering requirements of a future world market must be studied. In all these ways must the members of the Society do their part in order that the industry shall not come to a standstill, or even take a step backward. Members of the Society are now working on hundreds of different problems that need to be solved, and that will be solved. The part of the Society in all this is to encourage research work and to promote the presentation of technical papers that will serve as a guide to the members and to the industry as a whole.

Active Cooperation Required

This advancement in design can come about only through the active cooperation of the members among themselves. It will also be promoted by a larger and more representative membership. Active participation in the work of the Society must be secured from thousands of engineers and executives who are now actually engaged in the industry. Through the Society they will have every opportunity to broaden their own knowledge and vision by rendering disinterested service to the industry that in the end will be of the greatest value to themselves individually.

A large number of Society members have been called into the service of the Government in the present crisis. Many of the men most prominent in Society work in past years have been given positions as leaders in their respective fields. Consider, for instance, Past-president Howard E. Coffin, in his work as chairman of the Aircraft Board; Colonel Deeds and Colonel Walden, Lieutenant-Colonel Vincent, Major Marmon, and others, in the Aviation Section of the Signal Corps; Lieutenant-Colonel Alden, Major Wall, Major Glover, in the Ordnance Department; Christian Girl, as director of the Production and Engineering Branch of the Quartermaster Department and a large number of Society members who are helping him with the motor-truck program. All these men have been loyal supporters of the Society for years. It is not too much to say that the lessons learned from their S. A. E. activities as to the benefits of working together so as to get things done has been one of the greatest factors in their success in their present dealings with the automotive industries. These members regard the activities of the Society of the greatest importance in hastening the end of the war. Past-president Coffin, in concluding his address at the Annual Dinner last January, in New York, said: "I hope that those of us who are trying to do our bit down in Washington may feel that we have behind us the absolute support and the coordinated brains and activities of the Society of Automotive Engineers, and of this greatest of all the manufacturing industries of this country that it represents."

Appreciation of the Society's Work

This same feeling was expressed by President Wilson in his letter addressed to the members of the Society assembled at the Chicago dinner early in February, when he said: "It is very delightful to me to see the spirit in which they (S. A. E. members) approach the problems which are set for their solution, and I wish I might be personally present to express my appreciation and my confidence."

A statement made last June by Secretary of War Baker at the Washington dinner of the Society is another evidence of the opportunity afforded the members of the Society and of the appreciation with which their efforts have been received. Mr. Baker said: "My chief purpose in coming here was to urge, on behalf of my associates in the War Department, who are more immediately and directly charged with mechanical development of the great engines and instruments which are needed in this warfare, the hearty cooperation of the members of this Society and to thank them in their name for what they have done in the past."

The activities of the S. A. E. have been such that the advance of the industry has been measured by the efficiency of its engineering organization. At the present time we are putting to good use the lessons that were well developed in the early days of the Society. These lessons must be applied to still greater purpose after the war, when the spirit of working together, united effort all around, must be as characteristic of our whole industrial organization as it is now of many single groups, such as is represented by the Society of Automotive Engineers. It is as true now as it will be after the war, that if we all make up our minds to pull together then we shall all pull through triumphantly.

Kansas City Tractor Meeting

THE February issue of THE JOURNAL refers briefly on page 159 to the Society dinner upon the occasion of the recent Kansas City Tractor Show, but the meeting occurred too late in the month to include a full account of all the addresses in that issue.

The dinner took place on February 13, at the Hotel Baltimore, Kansas City. Nearly 200 members and guests of the Society were in attendance.

After the dinner, F. E. Place, vice-chairman of the Mid-West Section, called the meeting to order, and remarked that he had noticed a great improvement, over those exhibited last year, in the tractors at the tractor show, and believed the Society was entitled to share with the manufacturers a part of the credit for this improvement. He then introduced the toastmaster, Dent Parrett, chairman of the Tractor Division of the Standards Committee. Mr. Peake of the Kansas City Automobile Dealers' Association was first called upon by the toastmaster and made a few remarks welcoming the members of the Society to the automobile show, which was held simultaneously with the tractor show. In response to the toastmaster's introduction, Guy Hall, secretary of the Kansas City Tractor Club, and manager of the Kansas City tractor show, not only welcomed those in attendance to the National Tractor Show but extended his invitation to include the 1919 show as well.

THE S. A. E. EXHIBIT AT THE TRACTOR SHOW, INCLUDING A CLASS B MILITARY TRUCK ENGINE

Prof. G. A. Young, head of the Mechanical Engineering Department of Purdue University, Lafayette, Ind., next outlined the important part that Purdue University is taking in the testing of tractors, leading to the standardization of tractor parts.

Dean W. M. Jardine of the Kansas State Agricultural College, speaking as vice-chairman of the Kansas State Council of Defense, told what the Council is trying to accomplish in cooperation with the farmers, and pointed out ways in which patriotic tractor manufacturers could help to solve the food problem of the nation. His address appears on page 199.

H. L. Thomson of the Moline Plow Company took as his subject the tractor instruction book. His address is printed in full on page 200.

A. P. Yerkes of the Office of Farm Management of the Department of Agriculture discussed tractors from the farmer's viewpoint.

In referring to Mr. Yerkes' address, Toastmaster Parrett said that in his opinion the word "standard," as applied to a tractor, is a very much misunderstood term. He said that a standard, to be worth while, must be something that saves money and facilitates production. The object of standardization is not to limit the originality of the designer but simply to relieve him of much detail work on parts which can be used in different machines. "I was very much interested," said Toastmaster Parrett, "in talking with a prominent tractor engineer two or three days ago, to learn some of his views on standardization work. This engineer represents one of the largest producers of tractors. At my request he placed on paper a few of his ideas of standardization. It is interesting to note that these remarks come from a man who has taken no active part in standards work. These remarks were then read by E. J. Sweeney, at the request of Toastmaster Parrett, and appear below:

HOW S. A. E. STANDARDS WILL BENEFIT THE TRACTOR MANUFACTURER

"Many tractor manufacturers have a wrong impression as to the scope of work undertaken by the S. A. E. Standards Committee. The Committee's activities and thought are not to change existing designs of tractors entirely, but to standardize as far as possible those parts which are inherent and universally used as a part of each tractor.

"Standardizing such parts greatly benefits the manufacturer, and is particularly of assistance to his engineering department.

"It must also be considered that whatever standards are adopted will not necessarily be final, as in any growing industry it may be found necessary to make changes.

"In the past, before the Society became interested in tractors, most tractor engineers made use of standard S. A. E. specifications for their engine designs, and found them to be of great assistance and saving in time. Furthermore, they were used as a guide in selecting such details as have become standard with the trade, not only in material but also in tools for machining. For instance, standard hobs for different sizes of splined shafts can be bought, which would not be the case should every engineer specify his own sizes.

"What the S. A. E. proposes is to standardize other parts of the tractor in the same manner as has been accomplished on automobile and truck work.

"Heretofore there has been no standard height for the drawbar, every engineer making this what he considered fit or to suit his own special design. A standard height not only helps in designing but is a benefit to the plow builders or those manufacturing other implements to be hauled by tractors; heretofore they have been compelled to arrange their hitches to meet those of the different tractors, which vary in height from 10 to 26 inches.

"Before the entrance of the S. A. E. no standard of rating tractors was in vogue. The buying public and manufacturers should welcome such standardization. It

benefits the manufacturer by compelling all competitors to give their tractors conservative ratings, on the basis of what the tractor will actually do, and will stop the present practice of giving tractors fictitious ratings which cannot be supported by actual tests. A personal talk with some of the tractor representatives at the show convinced me that many false statements are given to the tractor-buying public.

"In asking one representative as to tractor performance I was given the drawbar pull at a certain speed per hour, which, when reduced to drawbar horsepower and compared with the size of engine, gave nearly 100 per cent efficiency.

"The tractor buyer is benefited and protected by the assurance that he will be given a standard power-rating, and not some high rating used only as a means to make a sale."

Standards Manager M. W. Hanks was then called upon, and read the following telegram from H. L. Horning, who was detained in Washington:

TELEGRAM FROM COUNCILOR HORNING

PLEASE convey to the members of the Society of Automotive Engineers and the Tractor Club of Kansas City my regrets at not being able to be present. My absence is due to military events of great magnitude impending. My plea of last year for standardization has been largely fulfilled. Standard war trucks and tractors will have interchangeable engines, and standardization has gone further than we can state for military reasons. I want to convey to the gathering my conviction that they hold the solution to many things which have direct bearing on our winning the war. First, land transportation, our main problem of the war, can be largely solved by the motor truck. Second, transportation by sea can be largely solved by prompt correction of land transportation. Food production can be greatly increased by the tractor, and to be of fullest benefit to us we must have better roads on which to transport food and all other commodities to rails and a right-of-way over clear rails to ports. We must have ships to keep our boys and Allies from want, which they have already felt. Every good American, therefore, must "pull" for good roads. They all lead to Berlin.

Standardization Simplifies Design

After commenting on the telegram, Mr. Hanks referred to the development of standardization and mentioned that a few years ago there were about fifteen different magneto mountings, but as a result of the work of the S. A. E. Standards Committee, there are now but two standards—one for automobiles and the other a small one for motorcycles. A few years ago there were six or eight different spark-plug threads. There is today one S. A. E. standard with American threads for automobiles, motor trucks, and tractors, and a metric thread spark-plug for the aircraft engines. Formerly there were about thirty different forms of tire rims but today this number has been materially reduced. Even in such a trivial matter as washers, formerly there were 2600 different sizes in use—today there are only about twenty-eight sizes of plain washers and twenty-eight sizes of lock washers to cover by far the greatest demand. Mr. Hanks closed his remarks by expressing a willingness on the part of the Society to cooperate to the fullest extent with the tractor manufacturers in the matter of standardization.

The toastmaster next called upon J. B. Bartholomew, president of the Avery Company, whose remarks are printed on the following page.

The address of the next speaker, David Beecroft, appears on page 195.

Capt. F. Monroe of the French Artillery, who is now instructing at the Brigade School of Fire, 164th Field Artillery Brigade, Camp Funston, Kan., gave a short but interesting address, referring in the course of it to the way in which tractors were used at the defense of Verdun. Capt. Monroe concluded his remarks with a toast to France and America which was received with great applause. His remarks ended the addresses of the evening, after which a motion-picture film was shown.

ADDRESS OF PROFESSOR YOUNG

MY interest in the tractor business began thirty years ago, when for two falls I was primarily interested in operating a steam traction engine during the threshing seasons on the prairies of South Dakota. I have often thought, not knowing what I know now, that I would not allow a man to clean a flywheel who knew as little about the essential parts and operation of an engine or boiler as I did in those days when my chief duty was to push in straw and blow the whistle to call the water boy or announce quitting time. I knew almost nothing about the engine or boiler, but Providence was kindly and allowed me to get this experience without mishap, and at the same time instilled in me the desire to be a mechanical engineer.

I believe that the time has come when the farmer desires and has a right to know, as well as the manufacturers of tractors, the unvarnished truth as to operation and performance of that machine which is playing so important a part in the operation of the farm today. I can well understand with what hesitation manufacturers have allowed themselves to think of standardization. They have not published in their catalogs facts of vital interest to the farmer knowing that such information would be taken advantage of by unscrupulous salesmen. I believe that possible danger is past and that the more the farmer knows about the tractor he is going to buy and operate the better he, as well as the manufacturer, will feel.

I am here, however, to tell what we are attempting at Purdue University in the way of testing and standardizing the farm tractor. It might be well first to note the facilities at Purdue which make it a desirable place for standardization work.

Purdue University's Testing Facilities

Purdue University has for years been ranked in the upper tenth of all technical universities as to number of engineering students. I believe she stands fourth today. We are all impressed by the size of the tractor show building but Purdue has a third more floor space, devoted to engineering laboratories alone, than the tractor building here at Kansas City. The total horsepower of the steam engines and turbines in our laboratories devoted to testing is about 2600, nearly 300 in internal combustion engines, not counting the farm tractors.

Purdue is perhaps most noted for its work in railroad

engineering and gas engineering. It was the first educational institution to have a locomotive mounted on wheels. Besides this, it has seven others in the railroad museum. Purdue was the first to design and build a machine for testing automobiles or truck chassis on wheels and the first to have an electrical dynamometer for testing gasoline engines. It was chosen by the Master Car Builders' Association to do all their work on brake shoes, car wheels, draft gears, couplers and air brakes. The M. C. B. machines for testing these are located in the laboratories at Purdue University. We have also done pioneer work in gas engineering.

When at Minneapolis, last December, I offered the Tractor Division of the Standards Committee the use of our laboratories to help them to standardize some of the features of the farm tractor. It is a source of gratification to us at Purdue that the committee accepted this offer and proposed a plan of cooperation. Within the year we have established at Purdue University an Engineering Experiment Station through which certain moneys and men are available for tractor standardization work.

As with the bicycle and the automobile, the market is at first flooded with different kinds of tractors, some of them freaks. We have seen some at the Tractor Show. It is simply a case of the survival of the fittest, for today that engine, that design, that construction which solves the problem and is to be relied upon will be the tractor on the market tomorrow. Our idea in standardization is not to have just one type of engine, one type of frame, or one type of wheel, but to bring out and emphasize a number of features which we recognize as theoretically, practically and commercially right, and then, without further effort on the part of the Standards Committee, the tractor manufacturer will group his designs so as to embody these features.

Testing Tractors

In regard to some of the plans under way for the actual testing of farm tractors: We will test the engine on the electrical dynamometer so arranged as to practically eliminate the personal element of observation. The weighing of gasoline, metering of air, measuring of power and counting the revolutions of the engine—these are all done by the throwing of an electric switch. We will also determine the belt-wheel horsepower by a dynamometer. The tractor will be mounted on supporting wheels in a manner similar to our locomotive. In this way the power available at the drawbar and at the rim of the driving-wheel can be determined irrespective of the nature of the soil. The engine will be tested on a standard gas, which does not vary from day to day or from year to year. By this means the results obtained three or even four years from now will be comparable with those of today. Then the engine will be tested with the carbureter and fuel recommended by the manufacturer, and the results compared. Finally, the Department of Farm Mechanics at Purdue will test the tractor in the field, determine its drawbar horsepower, its economy and field-operating features. The only thing yet to be done before getting this plan under way is the building of the apparatus for supporting the driving-wheels, and preliminary plans are now being worked out. That is the program. The object to be accomplished is a worthy one, so far-reaching in its results that we cannot afford to rush into it blindly. The part that Purdue University can take is important, but not so important a part as the manufacturers can take. Our whole aim is to assist them and the Standards Committee and to place our facilities at their disposal.

War Vocational Training

There is only one thing that may interfere with this program, and that is the fact that the Government has accepted the offer of Purdue University, and will send soldiers there for vocational training. What branches of training are to be given, and what departments will be affected, are not now known. As the training previously wanted was with automobiles and trucks, as well as with aviation engines, the school which I represent is likely to be involved. Should the Government send these men on between now and the first of April, it would take some strenuous work to maintain our tractor program and "do our bit" for the Government.

In closing, I wish to say that it has been a pleasure to come here, look over the wonderful tractor show, and restate our desire to place at the disposal of the great Society of Automotive Engineers Purdue University's facilities in money and talented engineers to help in the standardization of the farm tractor. I believe that when the war is over the story of the part the farm tractor will have played in winning the war will be written in letters of gold. When the farmer realizes, as many already have, that his farm horses are now cavalry horses, his hired men are drafted, his sons have volunteered, and the urgent call comes for still greater production, he would be helpless were it not for the farm tractor. I congratulate the manufacturers and the Tractor Division of the Standards Committee for their wisdom and judgment in pushing the development of one of the biggest possibilities now at our disposal for the winning of the war—*the farm tractor.*

ADDRESS OF MR. BARTHOLOMEW

THE question of transportation has become serious. Other manufacturers have told me of their experiences in the last few weeks, and I know of ours. Unless something is done to relieve the situation we are not going to be troubled by the shortage of tractors as much as by equipment to get them where the people want to use them.

There are, I believe, enough manufacturers in Kansas City at the present time so that three thousand flat cars, if placed tomorrow morning at the various factories, and properly distributed, would barely be enough to "catch up the slack" and take out the tractors ready to ship. From 16 to 20 in. of snow for the past forty days has kept *us* from thinking much about farming, but we are getting telegrams every day from all over the Southern States showing that *they* are thinking about farming right now.

If there is anything that this Society can do to relieve the car situation, it should be done immediately. In 1916 we put on eight tractor demonstrations, beginning in July, in Dallas, Texas, and moving north a week at a time until we finally finished the first week in September at Madison, Wis. The tractors were moved from place to place. We went into St. Louis with, I believe, seventy-nine flat cars of tractors, all to be unloaded on a platform barely the length of two cars, and to be in operation

the next morning after having been taken out into the fields and adjusted, plows set, etc. There was not a single tractor that was not ready the next morning.

Meaning of Standardization

The word "standardization" means just about the same to me to date as the word "camouflage." I have tried to master it, I have tried to follow the teachings of this Society, of which, by the way, I am not a member. Many of the standards established by the Society are all right, and I do not see why more are not established. I think the tractor industry is ready and willing to adopt all standards that can be fixed, and several such standardized parts that have been accepted by the tractor industry have been mentioned at this meeting. We use the same spark-plug and the same magneto base and the same magneto connection—the S. A. E. standards. We use S. A. E. carbureter connections and S. A. E. threads and bolts.

However, the talk about the proposed Liberty tractor, a standardized product somewhat after the fashion of the Liberty engine, has made me curious as to the effect of too much standardizing. To my mind it is unpatriotic for this Association, or any other body of men at this particular time, and under the existing conditions, to camouflage the American farmer with this standardization idea if it will cause him to sit back and wait for something that is going to be made.

What this country needs, according to the best solution that I can make, is bread. We need it in 1918, and probably will need some more in 1919.

For years, the wise manufacturer, when he has not known just how a new product was going to turn out, has kept it back home out on his own fields, or in a near-by friendly neighborhood, until absolutely sure the product would maintain his reputation and fulfill a reasonable warranty.

Now, we have heard considerable about the Liberty airplane engine and the Liberty truck. These may be exactly what the military authorities of the Government require, and what they want, and it may be that the parts can be made in different places and assembled in one place successfully. But supposing they can? An article which I read recently covering the idea of the standardized tractor—that is, the Liberty tractor—stated that there were too many kinds of tractors, too many types, and too many different sizes of tractors, and then suggested that the Government should, through a corps of engineers, introduce a standard design. Now, would not that be adding one more to the already too many designs on the market? What would be gained by it? And by what logic can a corps of Government engineers, even if they be taken from this Society, design a standard tractor and put it on the market without giving it a trial such as manufacturers usually have to give? I do not think that is good logic, and I do not expect it to succeed. I may be just a little off the subject in referring to a recent statement about tractors made by a prominent automobile manufacturer. This particular manufacturer has in mind a rather small tractor, and has suggested that it would have a great advantage over the larger ones in that, if for any reason the large ones were unable to proceed, a large amount of power would be lying idle, whereas the small one—a multiplicity of them—would not be likely to get in that same condition at one time. To talk about a little tractor in competition with a big one is camouflage. No manufacturer proposing to build a small tractor of the two or three-plow type has any legitimate right to start "knocking" another product that he is not at the present time, and never will be, in competition with.

I understand there are automobile people here as well as tractor people; the automobile people are very much interested in the tractor business. If there is not room enough left in the automobile business there is certainly room enough left for all in the tractor game.

Conditions in Tractor Industry

The thing that tractor manufacturers and farm-paper publishers, as a rule, are trying to work out is cooperation. Back in the early days of the automobile business there was much knifing among competitors, and I do not think they have got entirely over it as yet. There is no need of that in the tractor business at the present time, and one will not find any of the established companies decrying one another's products or their methods of doing business. They are getting along about as well and as agreeably as any set of men in business anywhere. We want to keep it that way.

When I started to build my automobile in 1900, after Duryea and Boley and Richardson and five or six others in our town had been working on an automobile (it was called then a motor buggy), the people of that town had become so thoroughly interested in it that they were ready to advise just how an automobile should be made in general appearance, and they said to me: "I understand you are going to make an automobile. Now, whatever you do, make it look just as much like a buggy as you can." I "fell" for that talk, and even went so far as to put a leather dash on it which I had bought from a buggy manufacturer. After driving around for two or three years I concluded that I ought to make that machine look like an automobile. Now, if any one is looking for a suggestion from me in regard to the designing of the tractor, be it the Liberty tractor, or any other, I would suggest that he make it look like a tractor.

Difficulty with Instruction Book

Mr. Thompson mentioned the tractor instruction book. The greatest trouble with the instruction book is that the farmer does not read it. I have made a careful investigation of that, and have had this idea of education pretty much in mind myself. I followed it up closely, and find that it does not seem to work. If any pressure can be brought to bear on the purchaser of a tractor to cause him to read the instruction book it is highly advisable, for the more he reads that instruction book (if a comparatively good one) the wiser he will be regarding the operation of his tractor.

There is one point that might be put in every instruction book to advantage: that any unusual sound or squeak in a tractor is a scientific signal put there to warn the operator that there is something he ought to do. If he will do that thing he will get along fairly well.

ADDRESS OF FIRST VICE-PRESIDENT BEECROFT

THIS is not simply a war of the boys over in France; it is just as much a war of the people at home. Somebody from the other side has stated that the present war is eighty per cent industry, fifteen per cent transportation and five per cent men. Now, we who are here are not in that five per cent men who are in the front line trenches. We are part of the eighty per cent industry and the fifteen per cent transportation, and it is just as necessary that we do our part in carrying on

this work as those who are on the other side. It is not fair that we require the boys who have donned the khaki to do all the training and we at home not take our due share.

How can we do that? How can we better attune ourselves to the efforts that are being expended on the other side? An Englishman sent to this country last fall gave advice as to how we can better attune our spirits to this expenditure of effort. He said that their experience in the war is that for three years and a half there have been three great sacrifices the people of Europe have had to make. The first great sacrifice was money. They had their loans—their first, second, third, fourth, fifth and their sixth. The first one was difficult, but they became easier and easier. The second money sacrifice was relatively easy, made on the spur of the moment in great drives as were our Liberty Loans. We are going to make our sacrifices of money to meet our Liberty Loans, but that is not doing all we have to do.

The second great sacrifice is of human life. It has come to almost every family among the Allies, but it is said even that sacrifice is not so great. It is met under the finest and highest impulses that throb in the human breast.

The third sacrifice, he said, and the greatest, is the one they have made as individuals and the sacrifice that we as individuals will have to make—he used the words "the sacrifice of individual prejudices." By "prejudice" is meant our traditions, the ways we have been accustomed to thinking, the habits we have formed.

Are we making proper sacrifices of our prejudices? Are we getting anywhere? Our boys are sacrificing lives, limbs, eyes and other parts. Now are we sacrificing our prejudices—getting out of our old ways of thinking? When our boys return home after peace is signed—those boys who are being re-created in this war, being remade physically and mentally—it will be a sad moment if they come back from the other side and find us going along in the same old pathway that they left us in in 1916 and 1917!

We at home must be new creatures when they come back or we will not be as worthy citizens of this great republic as those boys who return.

Now there are a great many ways in which we can re-create ourselves. It has been suggested that there are many train loads of tractors at our factories that should be on the farm. Perhaps it is our duty, as connected with this great industry, to use extra means and devise extra ways if our railroads are so clogged that they cannot move those loaded freight cars.

We expect our boys on the other side to pull those large guns miles and miles if necessary. We would not be satisfied, should their horses and tractors fail them, if they did not pull them by human power. If our railroads cannot move the tractors we must move them some way or other, under their own power if necessary. We should get out of our old way of thinking that waiting for the railroad is all we can do.

We recall the act of our Government last year in attempting to clean the snow off the great highways in order to move motor trucks, and there was the example of one of our states buying sixteen snow plows to keep the snow removed. We do not expect our boys in France to stop because there is snow, and why should we? It is up to us to go out and remove the snow and get vehicles to the places where they are needed.

As I said, we will be the saddest people in the world when peace is signed if we have not changed our spirits, if we have not progressed mentally, if we have not made those sacrifices of prejudice that will keep us as citizens of this country growing and growing on the same scale that we expect our boys on the other side to do.

ADDRESS OF CAPTAIN MONROE

IN Camp Funston, about a hundred miles from Kansas City, is a division, with three artillery regiments; one of them is a tractor regiment. This regiment has six batteries. Each battery has ten tractors, ten trucks, and five automobiles; that is, twenty-five for each battery—in all a hundred and fifty. We have not a truck for teaching purposes at Funston.

If any one thinks that an engine, or a sample part, especially a cross section, of any engine, tractor, or automobile, would be useful to teach officers, we would be very glad to receive it in Camp Funston.

Mr. Thomson stated that 90 per cent of the trouble with a tractor is due to lack of knowledge, that it is very easy to keep a tractor running for three days, but very difficult for thirty days. Those tractors in France may not run for thirty days, but perhaps for one, two, three or four years, because we do not know whether the war will end within one, two, three or four years.

I very often hear the inquiry from civilians in this country, "What can we do for the war? What can we do for you people in the army?" Here is an occasion to do something for us, and when I speak of "us" I mean Uncle Sam—the greatest buyer of trucks and tractors in this country. Uncle Sam asked the French to come here to teach artillery to his officers, and I am one of those sent.

It may perhaps be of interest to know what was done on the other side of the ocean by tractors and by automobiles. France and civilization were saved, I think, three times during the war: First, at the battle of the Marne; second, at the battle of Ypres; third, at the battle of Verdun. The battle of Verdun was won not only by the blood of several hundred thousand French soldiers (my brother was one of them) but by tractors and by trucks.

There was one great road between the railway and Verdun, and during perhaps four or five months four lines of tractors were constantly seen on this road, two going in one direction and two in the opposite; men kept going without rest day or night, perhaps twenty-four or forty-eight hours at a time, to bring supplies, ammunition and food to the soldiers.

The United States is a fortunate nation if it has but five per cent of its boys in the service, as I heard in one of the speeches of the evening. I believe that statement is correct. There are about a hundred million inhabitants, and two million soldiers. In France it is not the same. Before the war we had thirty-nine million inhabitants, and about half, twenty million, were men, and of those we had about five million soldiers. That is, twenty-five per cent.

This war is a question of industry, organization, and of soldiers. The greatest support was given to the Allies by this Republic in supplying all kinds of raw materials and food. Now, something more than that will be given—your boys. The greatest sacrifice a man can make is his life, because with his life will go all other sacrifices.

To go "over the top" is nothing, but to remain for days and days in the mud, bombarded, and keeping your courage—that is the great thing. I have been over the top with the infantry about fifteen times, and they were very proud moments in my life. However, after an attack, two or three days spent in the mud, in shell

holes, with only cold meat, or perhaps nothing, to eat, tire out nerves, and it becomes very difficult to set an example to the boys and to encourage them.

The five per cent—the boys who will go to France—should not be forgotten, but places should be kept for them in the factories and honors should be given to them upon their return. They should be honored with the best places in industrial life and the best places in political life, because these men will suffer more than those who remain behind.

Before becoming an officer I was an engineer, so I should be in a position to judge the industrial and the moral problems of the war; I consider that the greatest sacrifice in the war—whether or not the most important, certainly the *greatest* sacrifice—is being made by the enlisted men.

I want to say one more word. Lately I was asked what was my greatest surprise and my greatest interest in America, and my answer was this: I have been in America four months. It has the reputation of placing business ahead of everything, but I think it is at the same time a great idealistic nation, because, like the French people, Americans fight not for money but for ideals. The war that we are now fighting is a war for ideals, for liberty and for democracy, and that certainly represents the greatest communion and common ground between our two Republics.

ADDRESS OF MR. YERKES

THE committee which requested me to address the Society of Automotive Engineers stated that the principal subject was to be standardization, and although I informed them I had nothing new to say on this subject and no authority to say it, they insisted on my giving wordy evidence of the fact.

Tractors from the Farmer's Viewpoint

There are many and varied viewpoints on this question and much has been said on it that many do not concur in. The standardization problem is largely one for the engineer and manufacturer to deal with, but the user of farm implements is greatly interested in it, and I want to say a few words from his viewpoint, as it is with this phase of the subject that the Office of Farm Management is concerned.

First, I want to say that I cannot agree with the opinions expressed by some members of the S. A. E. to the effect that the tractor should be completely standardized through Government agencies, and the models reduced to one or two, which would be standard and would be produced by all manufacturers. There appears to me to be so many serious objections to such a plan as to make it very improbable that it will ever be followed out, while indiscriminate publicity along this line may easily cause considerable interference with the present tractor industry at a time when the production of tractors is of greater importance than ever before. But I do feel that there is strong need for standardization in tractor design along other lines which will be of great benefit to farmers who buy tractors, and increase the efficiency of the machines for farm work.

Delays in farm work are always serious, but this season there is probably more urgent reason than ever before to eliminate, so far as it is possible to do so, everything which hampers or delays farm operations. And when a farmer buys a tractor which he is unable to use satisfactorily on his grain separator, ensilage cutter, or feed grinder, without buying special pulleys, simply because the belt speed of the tractor does not correspond with that required properly to operate these machines, there is an unnecessary and expensive delay which could and should be eliminated by proper cooperation among the manufacturers of tractors and of machines which the tractor will be expected to operate. The same thing applies to the hitching of the tractor to many field machines; owing to the varying heights of drawbar, special devices must be procured in order to use the tractor with various plows and other implements. There are numerous other such points which might be mentioned, but with which we are all familiar. The S. A. E. Standards Committee has gone over these points and made recommendations, but this is the time for actions and not words; the standards which have been recommended by the Standards Committee do not help the tractor owner a particle until they are incorporated in the machines which are being delivered on farms, and I feel that the farmer is entitled to the fullest possible adoption of those standards which tend to prevent the above-mentioned delays in his operations, as well as by eliminating many of the cases where he is compelled to quit work with his tractor for several days or even weeks while awaiting the arrival of a small bolt or other part from a factory a thousand miles away, which should have been obtainable in standard form at almost any garage or repair shop.

Educating Tractor Users

There is another matter which, while not relating to standardization, is, I believe, about equally important, and I would like to say a few words concerning it. I refer to the educating of tractor users in the operation of their machines so as to enable them to obtain the fullest possible value from their use.

Farmers, as a class, are today much better educated than they were a few years ago, due not only to the better educational institutions, but to the agricultural periodicals. But even the best educated farmer is not usually competent to operate a gas tractor efficiently without some instruction in this particular line of work. Considering the important part farm machinery has played in placing American agriculture in its present position, it seems as though our various educational institutions have devoted too little time to teaching their students the efficient operation of such machinery.

Experienced tractor manufacturers have learned that their machines give the best satisfaction when handled by men who have had special training in handling the outfit, and several have found it to their advantage to organize schools where prospective users of their machines receive thorough instruction along this line. It does not seem as though this should be necessary any more than for growers of select seeds to maintain schools to instruct farmers in raising crops from such seed. In this, and subjects relating to farm live stock, we expect educational institutions to furnish the necessary instruction and these appear to be the logical means of educating farmers in the proper use of farm machinery. A number of the state agricultural colleges have already recognized the need for short courses on various subjects, at different seasons of the year. Judging by the list of colleges offering such short courses, as published in agricultural papers, there would seem to be, however, room for considerable improvement in this direction. I have heard some officials of state colleges make the statement that

there did not appear to be much demand for such courses in their state; hence they had never introduced them. I have been informed by some of the professors in farm mechanics at the state institutions which have offered such courses that more interest is shown in them than in any of the other short courses, and this is corroborated by my personal observation in a few of the colleges where it has been my privilege to be present during short-course terms.

Furthermore, I have talked to a number of men and boys who have received instruction in tractor operation not only at these short courses in the state colleges, but at private automobile and tractor schools, and have found them, without exception, very enthusiastic regarding them. They seem to be practically unanimous in their belief that the slight cost of instruction has been an exceedingly profitable investment because of the immense amount of time saved with the tractor in the field as well as the avoidance of repair bills.

As we all know, the importance of producing the greatest amount of foodstuffs in this country during the present season cannot be over-emphasized, and inasmuch as the tractor should have considerable influence in this direction, it is obviously highly desirable to take every possible action looking toward an increase in the efficiency of these machines on the farms, and I believe the two lines I have mentioned offer maximum returns with a minimum of effort.

Membership Increase

THE 1918 Membership Committee has now been formed, and has started its work of increasing the usefulness of the Society to the Nation and industry by the addition of all well-qualified engineers and executives throughout the country. As the plans have now been laid out, there will be two broad divisions to the Membership activities, the industrial and geographical.

The five members on the main Membership Committee of the Society will have supervision of the former. The names of these follow:

Second Vice-president C. C. Hinkley, the chairman of the committee, will represent the motor truck and car interests; Orville Wright, the aeronautical interests; T. B. Funk, the tractor interests; Charles H. John, marine interests; and Alfred P. Sloan, Jr., parts and accessories.

The way in which the geographical work will be handled depends on the number of members in a locality. The state has been taken as the unit for membership work. In states where there are sections of the Society these will take the general responsibility for the supervision of the membership work. In the states where there are no Sections, but where there are members of the Society, one member has been requested to act as a state leader of the membership work. In the case of the few states where there are no members of the Society, the work will be handled directly by the main membership committee, or through the New York office of the Society.

Steps have already been taken to start the state activities, and an effort will be made to get in touch with every member with a view to securing his cooperation for the benefit of the Society. The general work of the Society is of such vital importance that it is deemed necessary to secure the active cooperation of all qualified men in the industry. The members of the Society are naturally in the best position to judge of the non-members who are qualified for membership, and every member, therefore, should do his utmost to support the local leaders who will take charge of the work. A complete outline of the local organizations will appear in the next issue of THE JOURNAL.

Cooperative Use of Tractors

By W. M. Jardine* (Non-Member) KANSAS CITY TRACTOR MEETING PAPER

NOT as a representative of a manufacturing establishment, but as a consumer of their goods do I speak. My interest in tractors dates back to 1902, when I operated a steam tractor in Utah. In 1909 I operated a gasoline tractor in Montana. I enjoy the honor, I believe, of having unloaded the first steam engine used in Utah for plowing. That was in the early days of dry-farming, now one of the big fields of agriculture. I helped to start tractor farming in those western states. I had to, for I was born in the West and we had to make farming go or get out. Eventually I got out, but thanks to the perfecting of the science of dry-farming, with the additional aid of irrigation, that western country has been made a good place to live.

My experience with tractors about 1902 was not altogether pleasant. The manufacturers of the engine we bought would undoubtedly be as frank as I am now in admitting that none of us knew very much in those days about the pulling of plows with an engine, not even the proper way to hitch the plows to the engine. The manufacturers were generous, however, and sent a man who worked with us about six weeks, but we finally had to give it up. We did very well with the next, a gasoline engine tractor, as we plowed a thousand acres and then sold it for within $500 of the purchase price. Then we bought a 110-hp. engine and used it a while. I have, therefore, a first-hand knowledge of the development of the tractor and its use in the West and have learned the subject from the practical point of view. In recent years I have also been learning the use of tractors from the standpoint of an adviser of farmers. We have some 6000 tractors in Kansas now, probably 2000 or more of which have been placed in the state during the past year, indicating that Kansas farmers are rapidly coming to recognize the value of the tractor as an aid in overcoming the shortage of farm labor. We shall probably find it of still greater value this year.

Kansas Acreage to Be Plowed

It is as a representative of the Kansas State Council of Defense that I am here in company with Dean Potter, the head of the Engineering Division of the Kansas State Agricultural College and Secretary of the Committee on Labor, Horse and Machine Power of the Council of Defense. The government is asking all of the states to do more than ever in food production this year. There are 24,000.000 acres to be planted to crops in Kansas this spring. We have about 9,500,000 acres in winter wheat. Probably 1,500.000 acres of this area will be killed out, leaving 8,000,000 acres which must be harvested. Ordinarily, from 60,000 to 70,000 transient laborers come into the state to help with the wheat harvest, but there will not be many of these this year.

Kansas has already sent to the training camps or the front some 25,000 young men, half of whom came from the farms. Twenty thousand more will probably go with the next draft. They may be taken before the spring planting is done; if not, undoubtedly before the wheat harvest. Then large numbers of men have gone into industrial work. If 24,000,000 acres of spring crops are to be planted and more than 30,000,000 acres of crops harvested during the season, there is a big job on hand, the limiting factor of which will undoubtedly be labor.

Tractors Alleviate Labor Shortage

Being interested in tractors, I called the attention of the Council of Defense at its last meeting to the tractor as a possible source of aid in making the most efficient use of the available man-power in the state. I pointed out that a tractor of sufficient horsepower to pull a four-bottom plow, in the hands of a skilled operator, will plow from 10 to 15 acres of land a day; that a man with a four-horse team can plow 4 or 5 acres a day, and that, therefore, such a tractor outfit is equal to three such man-horse-labor units in plowing land for wheat. I am particularly interested in having tractors plow land for wheat, because with tractors it can be done early — in July and August — when it is too hot and often too dry to use horses.

Early Plowing Increases Yield

Everyone who knows anything about growing wheat—and we ought to know about it in Kansas where 9 or 10 million acres are planted every year—knows that we can increase the yield from 5 to 10 bushels an acre and even more by plowing the land in July and August. Every farmer knows this, but he also knows that plowing can be postponed whereas he cannot put off taking care of his alfalfa, cultivating his corn, stacking his wheat or threshing it if it is left in the shock.

It will not be possible to secure enough tractors to do all the plowing for wheat, but we ought to be able to increase the number materially. I am interested in getting groups of, say, a half dozen farmers to buy tractors cooperatively and put them in the hands of men who know how to run them. One of the chief drawbacks to the practical use of the tractor is the lack of skill on the part of the average man who tries to run them. Ninety per cent of the trouble is due to this cause.

COOPERATIVE TRACTOR FARMING

If we could ascertain those communities that have one or two thousand acres of land to be plowed for wheat whose owners would be willing to contract to have the land plowed by tractors, we might be able to place tractors in charge of skilled operators in those communities to do the work. Various means would be employed in bringing the land, tractor and operator together, and here is the opportunity for tractor manufacturers! The best way to convince farmers of the usefulness of tractors is to take the machines on their farms and demonstrate that they will do the work better and work more hours per day and more days per month than horses—not just show them that the tractor will plow thirty acres, then leave; the weakest tractor on the market will do that, but it takes a good tractor to plow steadily for thirty days and a good man to keep it going for that length of time. A skilled operator can do this, but the average farmer cannot. I believe it would be profitable, as well as patriotic, for manufacturers to place machines

*Vice-chairman, Kansas State Council of Defense.

on farms in charge of skilled operators who would give them proper care, and allow the operator to demonstrate to the farmer what the machine will do, the farmer paying so much, usually from $2 to $2.50 an acre, for the work done.

Men engaged in general farming cannot afford to waste their time trying to run machines they do not understand, especially if we can "round up" the men who do know something about engines, even if they are not experts, and put them to work. There are a number of such men. The Kansas State Agricultural College turns out several hundred short-course boys each year who have acquired a good working knowledge of tractors. These are scattered over the state. Last year we were in touch with a thousand that we could recommend as skilled operators. The number will be less this year because many have entered military service.

Cooperation of Kansas Council of Defense

The Council of Defense is getting in touch with the men in the state who can run tractors. We are also endeavoring to ascertain the farmers and communities who have land to be plowed with tractors, especially communities with a thousand acres and more. We will try to locate men who are willing to buy tractors cooperatively, as we used to buy threshing outfits, and employ men with knowledge of engines to run them. We shall probably find men who know how to run tractors and would be glad to do job work if they could manage to finance the purchase of machines. Some may have a little collateral, or perhaps some banker or business man will back them.

If tractor manufacturers are interested in the proposition of putting tractors on farms as I suggested, the Council of Defense will be glad to render every help, such as assembling jobs close enough together to avoid wasting time in traveling from one farm to another; also to have fair-sized tracts, although one of the sections of the state that needs this help is eastern Kansas, where the acreage planted to wheat and other crops is thought to be too small in many cases to justify the purchase of a tractor unless on a cooperative basis.

We believe in Kansas that the tractor is going to be an increasingly important factor in the development of our agriculture, especially after the war. The difficulty now is that the supply of tractors is limited. They are being shipped abroad. That is very desirable indeed, but we must not forget our home needs. Since we have banded ourselves with the Allies to win this great fight, we must distribute our resources where they will be most effective. This means looking after agricultural as well as military needs.

Besides being good advertising for the manufacturer, the cooperative plan of using tractors will render great assistance in the production of foodstuffs. Kansas crops are among the first to mature and become available for use. It behooves us, therefore, to facilitate their harvest and movement to market in every way possible. Tractors will do this. We need more in the state, and I hope we can get them "by hook or by crook." That is the thought I want to leave.

Heavy Tractors Needed in Kansas

I was astonished at the number of makes of tractors I saw assembled at the National Tractor Show, with the industry scarcely a decade and a half old! Farmers are thinking in terms of the heavy tractor. The tractor we need in this state, however, is the one that will do all kinds of work on the farm: Fill the silo; thresh the grain; plow the land; and pump water for irrigating. The little farmer can use the "baby" tractors. The "12-24" is the tractor that will meet our general needs in Kansas.

Tractor Instruction Books

By H. L. THOMSON* (*Non-member*)

KANSAS CITY TRACTOR MEETING PAPER

THE tractor instruction book may appear to some to be a relatively unimportant subject. It is usually looked upon as a mere appendage that has to be furnished, but it is a fact that a good instruction book properly placed in the hands of a farmer is a coordinating factor, equal in importance to high-class design and material, because it assures to that farmer maximum service from his tractor, if he will read and properly absorb the information contained in it. Sending a good instruction book with each machine is in a way as much of a war measure as building a good tractor.

Recently I have had occasion to examine many instruction books published by different tractor manufacturers and am glad of the opportunity to point out a few of their shortcomings and to suggest some improvements.

Some instruction books are very poor. Some have few or no illustrations. Others are poorly printed or employ a poor grade of paper. The cover stock is sometimes of such inferior grade that when oil-stained it is easily rubbed away by the fingers in handling. Naturally when a thing like that is sent out with a tractor the farmer is apt to conclude that the maker does not think much of his instruction book and in many cases he acts in accordance with that belief.

There are some fair instruction books and a few very good ones.

Too often the writer of the instruction book has the wrong attitude, starting with the assumption that the reader, like himself, understands gasoline engines. He then proceeds to skip many points that are clear to him, but the omission of which leaves absolute gaps from the farmer's point of view.

The remedy is plain. The writer must start as though telling a simple story in clear terms to a person who knows nothing about it. The farmer is not a stupid person; he is simply facing a brand new proposition.

Furthermore, some instruction books are written on the assumption that the tractor will never go wrong, that there will never be trouble of any kind necessitating thorough overhauling of the tractor. The farmer is told how to start his tractor, to crank it, to fill the gasoline tank, to lubricate, then a little as to how to

*Moline Plow Company.

run it in the field, and finally perhaps a little as to grinding valves or scraping bearings. We know that a person who has never scraped in a bearing cannot be told how to do it in three or four words.

Farmer His Own Service Man

The farmer must be the tractor man's field expert. He must be his own best service man. He must be the man on the field who, by reason of proper instruction, will be able to run the tractor right and keep it going and to fix it up when it requires repairing.

The farmer who is told that a tractor never will go wrong is not likely to believe it because of his experience with automobiles. He knows that they sometimes go wrong and have to be fixed. It is no confession of weakness at all for a maker to issue clear instructions for making a thorough annual overhauling of the tractor and properly taking up bearings, not only instructions for light repairs but for the major repairs which the tractor should receive.

I used to believe that the automobile helped the farmer to learn to run the tractor, but I am sorry to say that I do not believe it any more. The story is told of a tractor sold to a farmer who had had automobile and farm machinery experience. Shortly there was a call for an expert who went out and found the tractor burned out. He said, "How did that happen? Did you give it oil?"

The farmer replied, "Yes, I gave it oil just as often as I oiled my Ford."

He learned, and did not have any more trouble with his tractor. He needed a clear, concise instruction book and needed it impressed on his mind that he had to use that book.

Reducing the matter to mathematical form, I might say that: a poor instruction book = a little knowledge = a dangerous thing. Many instruction books are poorly arranged, with no general, reasonable, orderly plan as would naturally be expected in a book proceeding step by step to take up the different parts of a tractor. Some instruction books contain numerous technical terms. In others there seems to be an admixture of sales arguments. Neither should have any place in the instruction book.

Improving the Instruction Book

I wish to mention a few points in a constructive way concerning the design and material of this important service factor—the instruction book. As the farmer must be the real field expert we must try to make such instruction books as we would give our experts and put in such things as would be necessary for them to know to properly care for the tractor.

A poor cover goes very much against an instruction book. It should be durable. The size also should be considered and is a point, I believe, that could be standardized to great advantage. Some are big, some are little. A very favorable size, it seems to me, is one which could be carried in the coat pocket. Furthermore, instruction books are not placed in the farmer's hands in the right way. They are sent along in the tool-box. When he receives the tractor the farmer wants to run it and the instruction book waits for another day.

There should be a logical sequence starting with a certain part of the tractor and going to other parts in order—perhaps starting with the engine, then going to the transmission, then to the chassis—and taking up the things in each one of those sub-groups in a logical order.

It is difficult to grasp the ideas conveyed in long sentences and paragraphs. Frequent little sub-headings, blocked in in italics or in some other way to give a hint as to the subject matter of paragraphs will assist the farmer to find readily the material he is after when turning over the pages. He will not then be lost in a maze of words which make a book rather cumbersome.

The book should be made self-indexing. Instead of heading the pages with the name and address of the company there should be printed such words as Engine Ignition, Engine Lubrication, Transmission Bearings and Transmission Gears, so that when the reader thumbs across the book it becomes self-indexing at the top. There should also be a complete first-class cross-index in the back of the book, to enable him, by looking up any of the different names for the same thing, to locate readily its position in the book.

Like very many other men, a farmer is not a good reader of blueprints, if he has never seen the object to which a section drawing refers. Consequently, it is not usually advisable to describe by means of cross sections or regular mechanical drawings. One can get very much farther by showing something that looks like the tractor, either a photograph or a wash drawing with cut-in sections showing the various parts—and it is easier for anyone, whether a farmer or an engineer, to grasp.

There should be charts with arrows showing where to oil, and instructions telling how much to oil. These things should bring the information within the grasp in a very small space so that one does not have to wade through a volume of printed material to find instructions.

Educational Features

Another subject which has scarcely been touched is the use of educational matter in an instruction book. We sell a tractor to the farmer and tell him it is a labor-saving proposition that will do all his farm work. Yet if we have not given the farmer the knowledge of how to use that tractor to the best advantage, the result will be, in many cases, that he will dô indifferent plowing, not because he does not want to do good plowing, but because he does not know how to handle the tractor to do good plowing, does not know exactly how to get the right hitches and how properly to connect up to the belt.

Every instruction book should carry line drawings describing how the field should be laid off and explaining various operations; these educational features are just as valuable as instructions on running the mechanism.

I believe there is a psychological time to give the farmer the instruction book and I do not believe that it is when the tractor is delivered. It has been suggested that a favorable time to send the instruction book is after the farmer orders his tractor but before he gets it. At that time he is most interested in the thing which he is looking forward to and will readily read anything about it, as he wants to learn about it then. It is the same with all of us. I believe that this is the psychological time to present the instruction book. Then when he gets the tractor he will handle it the first week in an intelligent manner, and, of course, the first week in use is the hardest week in a tractor's life.

The manufacturer can follow up the instruction book with several letters—first, a general letter, second, a letter on the engine saying "Did you notice what it says about taking care of the engine on page so-and-so in our instruction book? That is very important." The transmission can be taken up next. Perhaps three or four letters with the instruction book will call his attention to particular things in the book and help him to grasp them readily, whereas if presented broadside to him, he might have difficulty in assimilating the whole thing at once.

To the person who is going to write an instruction book I would say, put yourself in the farmer's place. Explain carefully the upkeep, the operating and the field manipulation of the tractor as to a man who knows nothing at all about it. Such an instruction book printed on good paper with a first-class cover is the best service investment a company can make. It is one of the tools for getting more service out of the tractor. I hope this service tool will be sharpened up in the near future and that there will be a general redesign of this important service factor, the instruction book.

Private Aviators Now Require Licenses

A PROCLAMATION BY THE PRESIDENT OF THE UNITED STATES DATED FEBRUARY 28, 1918

WHEREAS the United States of America is now at war, and the Army and Navy thereof are endangered in their operations and preparations by aircraft, I, Woodrow Wilson, President of the United States, by virtue of the authority vested in me by the Constitution as Commander in Chief of the Army and Navy of the United States and of the militia of the several States when called into the actual service of the United States, do hereby for the protection of such forces issue the following proclamation:

1.—A license must be obtained from the joint Army and Navy board on aeronautic cognizance by or in behalf of any person who contemplates flying in a balloon, airplane, hydroplane, or other machine or device over or near any military or naval forces, camp, fort, battery, torpedo station, arsenal, munition factory, navy yard, naval station, coaling station, telephone or wireless or signal station, or any building or office connected with the national defense, or any place or region within the jurisdiction or occupation of the United States which may be designated by the President as a zone of warlike operations or of warlike preparation.

2.—The license will specify the person to whom it is issued, the machine to be used, the persons to operate the machine, and all other persons to be carried therein, the mode of marking or otherwise identifying the machine, and other details intended to assure the military and naval forces of the peacefulness of the errand.

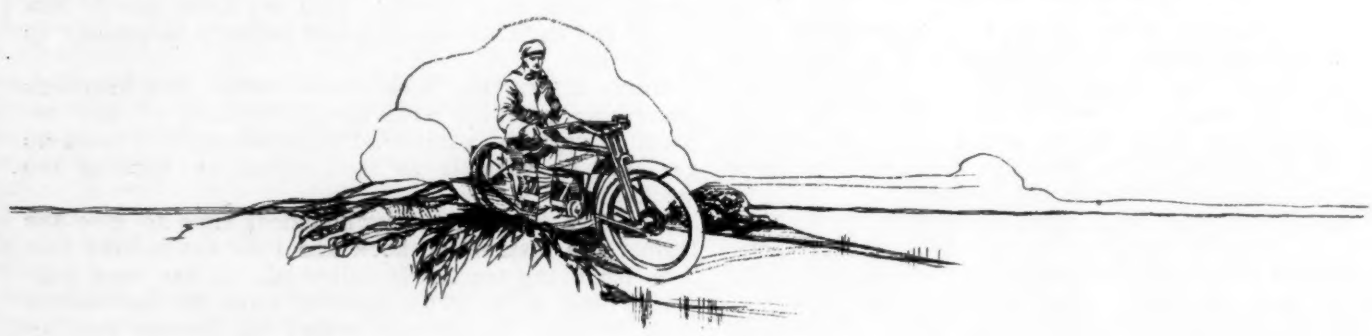
3.—The license will also specify the territory and the time wherein it shall be available.

4.—In case any aircraft shall disregard this proclamation or the terms of the license, it shall be the right and duty of the military or naval forces to treat the aircraft as hostile and to fire upon it or otherwise destroy it, notwithstanding the resultant danger to human life.

5.—For the present, the President designates as a zone of military operations and of military preparation the whole of the United States and its territorial waters and of the insular possessions and of the Panama Canal Zone.

6. The provisions of this proclamation do not apply to aircraft operated by the Army or Navy of the United States.

7.—No private flying without a license will be permitted after the expiration of 30 days from the date of this proclamation.



Vol. II March, 1918 No. 3

Flexible Fabric Universal-Joints

By C. A. Schell* (*Member of the Society*)

Indiana Section Paper *Illustrated with* Photographs and Charts

THE development of a new product in any industry is generally a gradual evolution from the crude to the highly refined, rather than an abrupt change from one fixed or proved construction to another. This has been so in the refinement of the flexible type of universal-joint and in its introduction to gasoline engine manufacturers, but considering that it has been in practical use in America for only about four years the promulgators of this construction have every reason to feel hopeful. At the present time there are over thirty-five truck and passenger car manufacturers who are using this joint as standard equipment, sixteen of whom use it on the propeller-shaft. All of these installations are

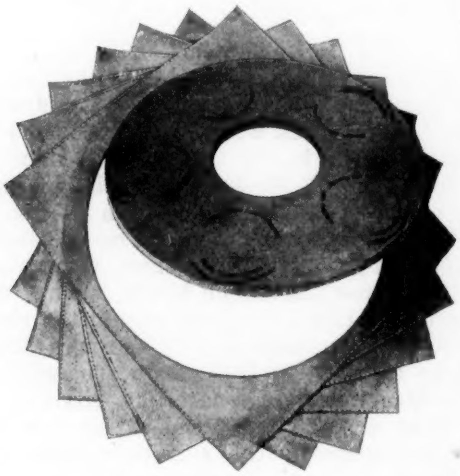


Fig. 1—Showing Method of Building up a Six-Ply Disk

giving good service, and their users are enthusiastic about them. Recent converts to this type of construction are the Studebaker Corporation, which uses it on all their models, and the Government, on the Class AA military truck; both use it between engine and transmission case. The Reo Company, which has used this type of coupling between engine and transmission case successfully for over four years, has finally adopted it on the axle end of the propeller-shaft. The forward installation was so successful, and was found to have so many advantages over the metal type of joint that it was finally adopted in the rear. The rear propeller-shaft joint generally gives the most trouble, being exposed to much dust and mud, and difficult to lubricate.

Some of the engineers who first experimented obtained discouraging results, in most cases owing to lack of knowledge of the fabrics and friction material required in the construction of the disks, and very often to lack of care and thought in the design of the metal parts. Some of the pioneer manufacturers of the disks are now building them very efficiently, and the design of metal parts is being gradually improved. In some of the first tests conducted it was soon learned that disks made of any ordinary grade of cotton and cheap friction material would not suffice. This type hardened very quickly under severe conditions, and failed just as a tire made very cheaply fails. Very good fabric must be used, and must be placed or woven correctly, the best grade of friction material employed, and the cure must be accurate in order to obtain a strong, elastic, and long-lived disk.

In building our first disks we tried several methods of weaving and of placing the plies of fabric relatively so as to obtain maximum results. We secured very good results from disks woven in six directions, or sectors, the cotton strands running completely around the disk, and equally good results from disks made up by the Hardy method. The first method proved very expensive, and meant the installation of intricate machinery. We also tried building up the disks by the straight method, or by laying one ply upon the next, with no attention to the direction of the weave, but the results were very discouraging. With this method we got uneven strength and stretching in the different sectors, even though in static tests they were as strong as the Hardy type. When on the road, the sector which happened to be in such relation to a set of bolt holes as to take the greatest part of the load failed very quickly. This is true because cotton is stronger when pulled in certain directions and stretches most when pulled on the bias; naturally with a three-arm type of spider the disk will not offer uniform resistance to the torque and an overload will always be thrown on one sector.

Construction of Hardy Disk

We finally adopted the Hardy disk, which is made by twisting the plies in consecutive fashion so that the disk is uniform in strength and stretch from any one portion to another, and when made of a good fabric has a tensile strength of 3000 lb. per sq. in. The Hardy disk had been used in England for several years prior to our experience with it, and is being used on several of the chassis over there at the present time. Of course,

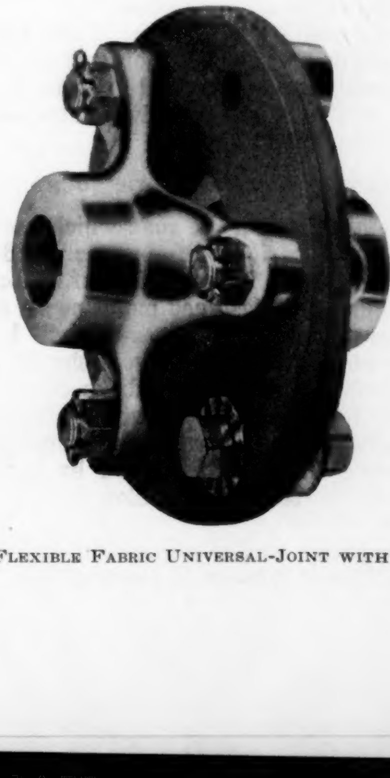


Fig. 2—Flexible Fabric Universal-Joint with Two Disks

*Chief Engineer, Thermoid Rubber Company.

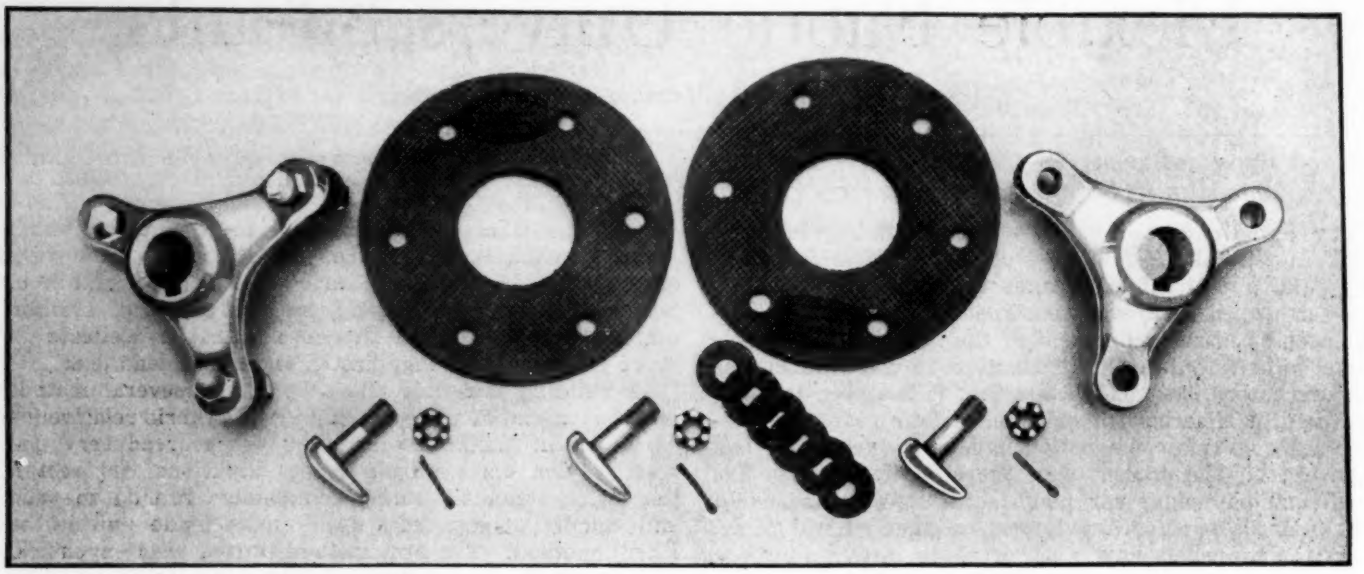


FIG. 3—COMPONENT PARTS OF A FLEXIBLE FABRIC UNIVERSAL-JOINT

disks of other constructions can and are being used, but in starting out we aimed to get the greatest strength and longevity that could be obtained in a given space.

We also aimed to get considerable elasticity in order to benefit all the chassis parts as much as possible, as the cushioning effect of elastic disks adds greatly to the life of the shafting, bearings, gears, transmission, clutch and even the engine.

After experimenting considerably with disks we went thoroughly into the metal parts of the joint and are conducting interesting tests at the present time. In testing some of the first assemblies that had given any trouble, we found that it was often due to the lack of care in designing the metal parts, and we have seen excellent disks fail owing solely to the use of poor friction washers. Most of the first washers were made too thin and allowed the fabric to pull out under the surface, throwing the load onto the bolt holes until failure took place. The washers should be made thick enough to resist cupping and should be fluted or knurled like a clutch-pedal in order to grip the fabric snugly and drive by friction. It is also good practice to groove or knurl the driving side of the spider bosses.

It must be remembered that the disks are comparatively soft, and that the volume or section held tightly under the washer face is depended upon to do the work; a disk made of the most expensive materials will fail, unless efficient washers are used.

Life of Flexible Fabric Joints

We have installations on the road which have run over 60,000 miles over a period of four years, and look good for some time to come. These consist of well-made disks of good fabric and well-designed metal parts, and we are satisfied that a well-balanced assembly will last as long as most present-day chassis. Even should it become necessary to install a new set of disks once during the life of the vehicle, the benefit derived by the rest of the chassis in the meantime is worth many times this expenditure. I believe the saving created by the use of a flexible coupling in the transmission line is not fully appreciated.

At the present time we are engaged in some laboratory work which will be of interest to the engineer. We have two well-known chassis, and with the use of special apparatus will attempt to show the failure points of certain parts under severe shock with and without the installation of flexible disks in the transmission line. This is a difficult task and will require time to be put in conclusive form, but from present observation we are sure the results will be almost astounding. The greatest benefit is obtained on trucks with solid tires, when chains are employed. It is not uncommon to see a truck with two or three pieces of chain wrapped around the rear wheel started with an unmerciful jerk by a rough driver, and in such cases a small shock absorber somewhere in the drive is an advantage. In a case like this a good disk-joint will allow about 5 deg. wind, which means a considerable time element; the cushioning effect of the Hotchkiss drive is small in comparison, especially on trucks with huge rear springs.

Use with Hotchkiss Drive

One of the strongest arguments for the use of the Hotchkiss drive is the flexibility of transmission; therefore, with the installation of the flexible coupling in addition a still greater cushioning effect is obtained; of course, this cushioning can be obtained even on fixed axles with the coupling, and, as stated above, to a much greater extent than with the Hotchkiss drive itself.

After experimenting and going thoroughly into the proposition, both in the laboratory and on the road, the Studebaker Corporation has adopted the flexible disk as a clutch-to-transmission coupling on all of its new chassis. The engine in the large Studebaker chassis develops a torque of about 2400 lb.-in., and in this case a single disk $7\frac{1}{2}$ by 13/32 in., consisting of 10 plies of fabric, is used. By actual test this disk will fail at a torque between 12,000 and 13,000 lb.-in., pulling through $1\frac{3}{8}$-in. washers. This complete assembly, compared with a metal type for the same place, is lighter, requires no attention, eliminates backlash and noise and adds greatly to the life and safety factor of all metal parts. In the Studebaker disks the bolt holes are on a $5\frac{5}{8}$-in. radius with $1\frac{3}{8}$-in. washers. With the use of a four-arm spider, this gives an effective driving section of $2\frac{1}{4}$ sq. in. of fabric, having a tensile strength of 3000 lb. per sq. in. Therefore the disk will carry a 6750-lb. load

at the bolt-circle radius. The torque at this distance from the center equals 850 lb., consequently this assembly has a very high factor of safety.

Class AA Military Trucks

Two of the engineers on the committee designing the Class AA military truck have had previous experience with flexible joints, and, seeing them successfully used, have laid out a well-balanced assembly. Two disks per joint are used, of 6½ by 5/16-in. material with a 1¾-in. fluted washer, with three-arm spiders. The engine develops 1800 lb.-in. torque, hence this will prove a very

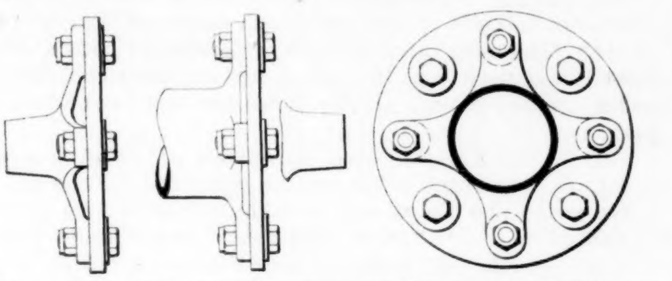


FIG. 4—FOUR-ARM TYPE OF COUPLING FOR USE BETWEEN ENGINE AND TRANSMISSION

successful unit, with an ample factor of safety. For engine-to-transmission-case couplings, many designers are now using the four-arm spider similar to the Studebaker, taking advantage of the fourth arm for extra strength,

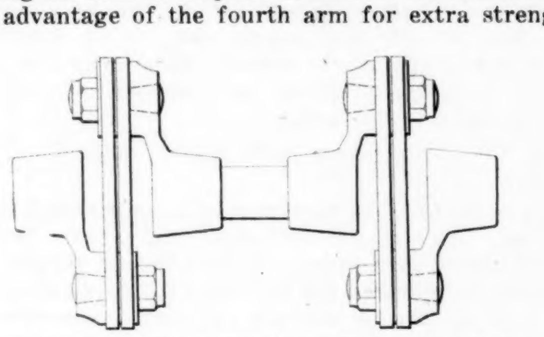


FIG. 5—TYPE OF FLEXIBLE FABRIC UNIVERSAL-JOINT USED ON CLASS AA MILITARY TRUCKS

thereby saving fabric and making a slightly cheaper assembly. This construction decreases the flexibility slightly, but not much is required as only chassis variation and weaving are to be taken care of at this point.

USE BETWEEN ENGINE AND TRANSMISSION

For installation between engine and transmission the flexible coupling eliminates all bearings and splines, thereby avoiding the possibility of noise and doing away with the inconvenience of greasing. In addition it reduces severe shocks, makes easier the shifting of gears and owing to the above qualities adds greatly to the life and safety factor of all metal parts.

Propeller-Shaft Joints

In laying out propeller-shaft joints many factors besides torsional load are to be considered, the angle and amount of lateral movement being the most important. On account of these conditions the three-arm type is the most practical and is the only one now used. The diameter and thickness of the disks are partly dependent on the lateral movement and angularity, and should have capacity enough to take care of the increased torque while in low gear. The average light six now in vogue in this country requires a three-disk coupling from 7 to 8 in. diameter, either ¼ or 5/16 in. thick.

An installation of this size takes care of the average angularity and requires no spline for lateral movement. As the trend of design is toward flat springs and straight propeller-shafts, it will be possible to equip more cars each year as this element cuts down the work of the disks to a minimum, making conditions ideal for this type.

Contrary to general opinion, the thrust required to stretch the disks to take care of lateral axle movement is very slight. The variation is taken up in two sets of disks, and if a total of ¾ in. is required, then each coupling must move only 3/16 in. either way; this requires less than 40 lb. total pressure on the average passenger car. The load imposed on adjacent bearings due to tipping is also very slight but is dependent on the angle. We have several rear assemblies now running over 40,000 miles which have an average shaft angle of 6 deg., with a maximum of 10 deg., but in going higher than this the outside diameter should be very closely watched.

Many of the first engineers to try out propeller-shaft couplings had considerable trouble with vibration. This was very often due to poor machine work or a bad combination of disks. Several light cars, both fours and sixes, with fairly high-speed engines, are now using the rear installations, and when the assembly is properly machined experience no trouble of this kind. The vibration led to the installation of centering devices, and some of these were not very successful. When extremely high speeds along with large angles are encountered a good centering device will help to cut down the small amount of vibration which may develop; however, on the average light six of the present period we have not encountered any serious trouble of this sort, and one very popular light four equipped with high-speed engine shows none whatsoever at 50 m.p.h. One of the large truck makers using this construction puts a pressed-steel disk over the fixed spider fitting closely around the disk thereby causing the disks or floating spiders to rotate truly within the shell. The centering device, we believe, can be used to advantage under extreme conditions, but on the average car is unnecessary. Of course, when a large angle with extremely high speed are combined the shaft will rotate

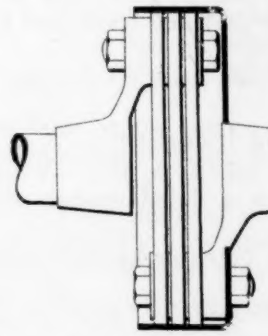


FIG. 6—STEEL DRUM USED AS A CENTERING DEVICE

elliptically—to a greater extent than when conditions are more moderate. Today several light sixes are being equipped with three-disk joints which we consider average as regards speed and angularity of drive. An average shaft angle is 5 deg. with 4½: 1 axle reduction and a total lateral axle movement of ¾ in. None of these installations have a centering device or a spline, but they are giving good results. For slower speeds

larger angles can be used. If the hole in the center of the disk is not too large the disk will be very strong in a direction outwardly from the center, and still be flexible laterally. Naturally the floating spiders will be kept running in a very small ellipse, therefore keeping the assembly from whipping. We do not wish to convey the idea that the flexible joint can be mounted on any and every chassis as such is not the case. We have them on the final drives of 4-ton worm-driven trucks, and on fairly high-speed light touring cars; when the conditions are right, the angle not too great, or the speed too high combined with a large angle, the results are excellent, saving the designer much worry about noise and lubrication troubles.

We have found it unnecessary to pay particular attention to the position of pinion-shaft in relation to transmission main-shaft. Due to the stretching of the fabric, practically no variation in the speed of the pinion-shaft occurs on the average installation.

We have a Hotchkiss-driven chassis at our factory which contains a very good low-speed engine, and has a propeller-shaft mounted at about 8 deg. with the car light. With the metal joint installed the pinion and transmission shafts must be lined up very carefully in order to get smooth low-speed performance and eliminate a slight jerking of the car. With the use of the flexible joints, we have placed these shafts in every conceivable relation to each other and still get smooth action.

A complete shaft assembly with well-designed metal parts weighs about 80 per cent as much as a metal joint of similar capacity. It requires no attention, cuts out backlash, adds to the safety factor of the other chassis parts and acts as a sound insulator between axle and frame. We feel that our confidence in this type of construction has been justified by the success its adherents are having with it. We predict it will be almost universally used between engine and transmission case within the next few years, and that for propeller-shaft installation it will give the metal type a very stiff argument for predominance.

THE DISCUSSION

H. G. McComb (M. S. A. E.):—About how long ago were these first used? Were they brought out first in England and who used them first?

Mr. Schell:—I believe they were first used on the Isotta-Fraschini in 1911 and were used in England soon after.

Mr. McComb:—Does the Fifth Avenue Coach Company use them?

Mr. Schell:—No, it does not.

Max H. Thoms (M. S. A. E.):—When several disks make up a joint, is a fluted washer used between adjoining disks?

Mr. Schell:—A fluted or knurled washer is used between each disk.

Effect of Oil and Heat.

Mr. Thoms:—What effect do oil and heat have on these joints?

Mr. Schell:—An excess of oil will eventually destroy cotton or rubber but on the average chassis the disks do not come in contact with enough to harm them. Under very extreme heat they will become brittle and eventually crack.

Lieutenant Meyers:—In the trucks used for road work by the Barrett Company the universal is so situated that it is exposed to the tar, which is, of course, a much more solvent agent than oil. The universals have been tested out carefully—I think forty-eight were tested in a bath of tar around 400 deg.—and there was no effect, practically, in disintegration of the fabric; but one of those universals was mounted over the muffler, and that, in the course of two or three months, showed some disintegration, owing to the heat. That was the only trouble experienced.

Material Used

Mr. Thoms:—Is the material used like brake lining—that is, interwoven with fine-meshed brass wire?

Mr. Schell:—The material used in the construction of the disks is made of selected cotton duck and high grade rubber. The duck is made of three grades of cotton, Sea Island, Egyptian, and the best grade of American cotton called combed peeler. Of the three the Sea Island is superior.

Mr. McComb:—Has that movement of about 5 deg. really an important effect on the operation of the car? Some years ago there was brought out a flexible shaft composed of a number of bars that were actually rotationally flexible. It seems to me that if there had been much in that principle, it would have been developed. There is only about 1/72 of a turn, so far as rotation is concerned, due to 5 deg. action of this joint.

Mr. Schell:—The variation in speed depends upon the angle of the propeller-shaft. On a chassis at our factory which has a shaft mounted at 8 deg. we get a noticeable variation at very low speeds when using metal joints which are improperly mounted. Because of the stretching of the fabric in the disks, this does not occur when flexible joints are installed.

Mr. McComb:—Is the jerking effect noticed only at low speeds?

Mr. Schell:—The variation in propeller-shaft speed is naturally there at all car speeds but is only noticeable when running very slowly. Most of the metal joint manufacturers recommend the mounting of their joints in certain relation to one another in order to overcome this speed variation.

Maximum Life

E. B. Reeser (A. S. A. E.):—Have these joints been in use long enough to determine the maximum life, in mileage?

Mr. Schell:—The Reo Company has been using a forward installation for about $3\frac{1}{2}$ years and I know of some of these cars that have run over 60,000 miles in this period. Several motor trucks have used the rear installation for 3 years over a distance of about 40,000 miles.

C. S. Mott (A. S. A. E.):—Can the weight of the driving shaft be decreased by the use of joints?

Mr. Schell:—A well-designed flexible joint will weigh considerably less than a metal joint of similar capacity.

Mr. Mott:—We had considerable trouble because both joints were operative at all times. There was excessive spring action and I believe the slippage on the spline was from 3/5 to $\frac{7}{8}$ inch. Has anyone had experience running with a gear ratio of say 5 to 1 at fairly high speeds?

Mr. Schell:—We have installations on light sixes that have gear reductions of $4\frac{3}{4}$ to 1, the engines turning over at 2500 r.p.m., and they are very successful.

Mr. Mott:—It has not been tried out on anything much heavier, then, at high speed? For instance, on an eight-cylinder, with fairly good torque, from $1\frac{1}{2}$ up to 60 miles, with drive shaft 56 in. long?

MR. SCHELL:—One Western company is using the installation on a twelve-cylinder model that weighs about 3500 lb. The engine is of fairly high speed and develops about 60 hp. The rear axle ratio is close to 5 to 1. The drive-shaft is about 59 in. overall.

MR. MOTT:—On this particular job, the springs have considerable bow. Is a spline slip advocated with a Hotchkiss drive?

MR. SCHELL:—If the lateral movement is not over 7/8 in., I would not use a spline. The diameter of the disks will be in proportion to the amount of power transmitted. What was the torque capacity of the engine?

MR. MOTT:—I do not know exactly what it was rated, although it gave 56 hp. at 2600 r.p.m.

C. S. CRAWFORD (M. S. A. E.):—That would be about 150 lb.

MR. SCHELL:—A 7½-in. disk would be appropriate for this chassis.

Proper Number of Bolts

MR. THOMS:—If there is any play to be taken over by the universal-joint, would it be preferable for the joint to have four driving bolts, or should it have six? With so much play the material is stretched way beyond the safe load or safe strain.

MR. SCHELL:—All the propeller-shaft installations today incorporate a three-armed spider which is flexible enough to take the lateral movement and gives three driving sectors. If the two-armed spider is used naturally only two-thirds of the effective material is utilized and the disk must be larger in proportion to transmit a given load. Where the lateral movement is very large it would be advisable to use a spline in connection with a three-armed spider rather than adopting two-armed construction.

JOS. E. PADGETT:—Is there any difference due to continuity of impulses in the life of those used with four-cylinder engines, and those with a greater number of cylinders?

MR. SCHELL:—Naturally with a four-cylinder engine the torque is not as even and this is generally allowed for in laying out an installation. We have noticed no great difference in the life of an assembly in connection with different numbers of cylinders.

MR. MCCOMB:—For the same load, how much larger in diameter are the fabric than steel joints of standard construction?

MR. SCHELL:—The flexible coupling generally requires from one to two inches more space than a metal joint of the same capacity.

Lubrication of Metal Universal-Joints

MR. CRAWFORD:—I think the tendency is always to use the smallest thing on the data sheet. Conditions are constantly changing and when figuring these things out, it is best to have the engineer on the ground to work out the problem with one. We have one job that has been run a little over 10,000 miles, with 6½-in. drive. A larger drive was recommended to us, but we wanted to see the smaller one in operation first. It has two disks and a three-arm spider. The lateral movement on our job, however, from the first rebound to the bumpers against the frame, was only 3/8 in. The springs are practically flat. The maximum angle is about 7 deg. That car ran on the Speedway for most of the 10,000 miles at an average engine speed of 3200 r.p.m. Our job is not altogether immune from oil, and I know the disks are soaked with it, but we have never noticed any disintegration due to the oil at high engine speed. One can run up to 3500 or 3600 r.p.m. in second-gear, at which speed there is a bad whip in the drive. However, I have never seen a metal type universal-joint that would stand a half day's running on the track and hold the lubricant. The joint becomes so hot at that speed that it burns out all the lubricant we have ever tried. The lubricant may stay in the housing, but the joint becomes so hot it melts the lubricant around the housing and the pins there then start to gall, unless the pistons are fitted very loose, and then there is much noise. A pilot might be used for the central part of the drive to support the shaft. I think that could be worked out well, without getting any wear and without any lubricant, especially where there is very slight slippage. I think the lubricating problem is the one thing against the metal joint. We have had more trouble with that than anything else.

MR. THOMS:—Nevertheless, they run racing cars with those joints.

MR. CRAWFORD:—I know they do, but I do not think they run them at these engine speeds, and in racing cars the drive is as straight as possible. Racing cars are lashed down and do not bounce around. I think conditions differ with passenger vehicles and racing cars. A racing car has not the load that a touring car has, nor the top and windshield.

MR. SCHELL:—In regard to lubrication, we carried on a very unique experiment in New York City about four weeks ago. Several of us were of different opinions as to the service the metal universal-joint generally gets on the average car. I made a wager that eight of every ten owners who drove their own cars did not know when their joints had last been greased or inspected. We left the club and approached the first ten owners of cars which we happened to meet; we picked out only men who did their own driving. Instead of eight not knowing anything about their joints we found that the entire ten did not know. We asked several why this had not been taken care of and some said they did not know that joints had to be greased. I asked one man if he ever read his instruction book; he very intelligently informed me that people who wrote instruction books generally knew nothing about automobiles. One informed me that he did not know that he had an instruction book. Most metal universals, if designed with ample bearing surfaces and given proper attention, are very successful; but this little experiment showed us that the average car is not given a very square deal.

MR. THOMS:—What is the comparative power loss in driving through an angle with this type of coupling and a metal coupling?

MR. SCHELL:—We are carrying on experiments to determine this at the present time and will know exactly from actual tests in the very near future.

MR. MCCOMB:—Why have not more high-grade cars adopted this type of fabric joint?

MR. SCHELL:—New and advantageous developments are not always adopted by builders of high-priced cars, although several high-priced trucks and passenger cars have been using them for some time.

MR. MCCOMB:—Are they not being used only between the engine and transmission?

MR. SCHELL:—A number of cars are using them on the propeller-shaft.

Comparative Cost

MR. MCCOMB:—They have been used so much in motor-

boat service, it seems odd that more automobile manufacturers have not come to use them. Has the price operated against it?

MR. SCHELL:—The price at the present time is about that of a good metal universal-joint installation. This is kept high due to the abnormal cost of cotton used in the manufacture of the disks.

MR. CRAWFORD:—If the car manufacturer would make the chassis changes to take care of the conditions under which this joint should be used, more of them than the other type would probably be used, and if he would do the same thing for the metal joint, he would no doubt get much better results. I do not believe the application of universal-joints to cars has had the serious consideration that it should have.

H. A. VOST:—I notice that in several joints spoken of three 5/16-in. disks were used. Can two 3/8-in. disks be substituted?

MR. SCHELL:—Two could be used but in using the three two additional frictional driving faces are obtained. Naturally, with a lower given torque less surface friction is required for driving.

MR. VOST:—For the man who has a light car, and two 5/16-in. disks, the use of three 1/4-in. disks would be recommended?

MR. SCHELL:—In such a case I think the three 1/4-in. disks would give the best results.

MR. VOST:—I would like to know the tolerances allowed in fitting the disks on the studs?

Bolt Holes

MR. SCHELL:—The bolt holes in the disks are made the same size as the bolts, which must be forced slightly when assembling.

MR. THOMS:—Are the holes punched midway between the outer and inner edges of the disks?

MR. SCHELL:—We do not put the bolt holes in the center of the fabric. They are slightly out from this as the factor of flexibility must be taken into consideration on this point.

MR. THOMS:—Have not some elliptical washers been used?

MR. SCHELL:—We have used elliptical washers and still use them where not much angularity or lateral movement is needed but, on the rear installations, are getting best results with the round fluted washer.

MR. SMITH:—Is it not a fact that on high-speed engines the disks loosen up, so that the two ends of the rear shaft from time to time rebound, causing considerable vibration?

MR. SCHELL:—With large angles and extremely high speeds we have had some vibrational trouble. This can be overcome with the use of a centering device but, as stated in my paper, on the average chassis we find this unnecessary.

Disk Diameters

MR. SMITH:—My own experience, on a small car, is that the disk should be greater in diameter in proportion to the horsepower used. Is that not true? For instance, a 5½ or 6-in. disk is used on a 30-hp. engine and possibly a 7 to 7½-in. disk on a 50-hp. engine. That may show that the relatively larger diameter gives better results on the smaller car.

MR. SCHELL:—The diameter of the disk is generally in direct proportion to the power transmitted and we have been getting just as good results with 7½-in. or 8-in. disks as we have with the smaller ones. Of course the lateral slip and angle must not be neglected in designing a joint. Many of those who experience this trouble do not pay very strict attention to machining the parts accurately. This is as essential as in machining a metal joint. Some of the first assemblies were equipped with disks which were too flexible and were built with too large a center hole; this made the disk too weak to overcome the centrifugal action due to working on an angle.

ORGANIZATION OF EMERGENCY FLEET CORPORATION

THE United States Shipping Board was organized under the Act of Congress approved Sept. 7, 1916. The duties of the Shipping Board are to regulate carriers by water engaged in foreign and interstate commerce of the United States and to establish and develop a merchant marine.

Section 11 of the Act referred to above authorizes the Board to form, "under the laws of the District of Columbia, one or more corporations for the purchase, construction, equipment, lease, charter, maintenance and operation of merchant vessels in the commerce of the United States."

Pursuant to this authority the United States Shipping Board Emergency Fleet Corporation, capitalized at $50,000,000, was incorporated April 16, 1917. The Board may at any time sell any or all of the stock of the United States in this Corporation, but at no time shall it be a minority stockholder therein.

The Emergency Fleet Corporation is constructing under contract vessels for the United States commerce. It controls production and inspection of work on such vessels; new plants and plant extension, and housing problems in connection with such plants; supervises the completion of requisitioned vessels and operation of commandeered yards; purchases, inspects, and arranges for shipments of shipbuilding materials, and adjusts legal questions affecting contracts and labor.

Personnel

The general executive officers of the corporation are: Edward N. Hurley, president; John A. Donald, vice-president; Charles Piez, vice-president and general manager; R. B. Stevens, treasurer; Lester Sisler, secretary, and J. L. Ackerson, assistant to vice-president and general manager. The trustees are: Edward N. Hurley, Charles Piez, John A. Donald, R. B. Stevens, Bainbridge Colby, and Charles R. Page.

Emergency Fleet Corporation Divisions

THE CONSTRUCTION DIVISIONS, with headquarters at 1319 F Street, N. W., Washington, D. C., have supervi-

sion over technical matters connected with the design and construction of vessels, the control of production and inspection of the work on vessels under construction, both as regards vessels building under contract for the corporation and of requisitioned vessels, as well as the operation of commandeered yards. Under Steel Ship Construction, all matters connected with the requisitioning of vessels under construction are administered, as well as the operation of the three large fabricating shipyards. The Technical Department of the Division of Steel Ship Construction has charge of all original designing work and the supervision of all technical matters connected with vessel construction. The Department of Industrial Training, also under the same division, has charge of the training of men for shipyard operations—training schools for this purpose being established near many of the shipyards. The Division of Wood Ship Construction also has charge of all matters connected with the design and construction of composite and concrete vessels.

The Purchasing Division, located in the Munsey Building, Washington, has the duty of purchasing machinery and equipment complete for ships contracted for on a "hull only" basis; purchasing certain machinery and equipment for hulls contracted for on a "complete ship" basis; purchasing lumber for wooden ships; lumber, piles and cross-ties for shipyards; steel for steel ships; raw and semi-finished materials for machinery contracts, and inspecting machinery and material in process of manufacture.

Branch offices of the Purchasing Division are maintained at New Orleans, Seattle, and San Francisco.

The Shipyard Plants Division, located in the American National Bank Building, Washington, has supervision of all matters relating to the establishment and inspection of work on new plants for the purpose of determining the suitability of such plants for the building and launching of vessels, having in mind their safe completion and launching without delay. Its work particularly comprises that part of the ship contracts with the Emergency Fleet Corporation applying to grounds, water fronts, wharves, shipbuilding ways, handling equipment at ways, railroad and track equipment, fixed and movable cranes, shops, buildings, power plant, distributing systems, installation of tools, and in fact all equipment necessary for the construction of ships, and conducts conferences and correspondence in reference thereto. It also has jurisdiction over matters of fire protection and of providing ample shipyard protection.

The National Service Division, just formed, has to do with welfare and sanitation, the Shipyard Volunteer Reserve, industrial service, national service and shipyard meetings, the problem of housing shipyard employees, and transit facilities.

The Contract Division, 1319 F Street, N. W., has supervision over conferences and correspondence and conducts the preliminary steps connected with the investigation of all questions (including credits), relating to the negotiation of contracts up to the point of formulating the form, scope and general terms of contracts.

The Auditing Division, 406 Seventh Street, N. W., has supervision over all matters connected with auditing, accounting and payments under contracts and other disbursements; and investigates and reports on matters of credit. The Insurance Department under this division has charge of the insurance on all ships, plants and other property of the corporation; this insurance being carried by the corporation itself, instead of being placed among insurance companies. The Auditing Division is represented in each district by a district auditor and a staff of resident auditors, in addition to which it has five local auditors and their staff assigned to special propositions, such as fabricated shipyards.

The Legal Division, 1319 F Street, N. W., handles the preparation of contracts for ships (both wood and steel), housing, dry docks, material and equipment, after the scope and general terms thereof have been decided by the division handling the preliminary negotiations, and approved by the vice-president and general manager; all matters of a legal nature arising out of the general questions of ship construction, housing, labor, legislation, financing, transportation, power, commandeering and requisitioning, taxation, ship transfers, and opinions in regard to rights and powers of the corporation and also in regard to the obligations of the Corporation under its contracts. Also litigation and claims both for and against the corporation.

The Production Division, Munsey Building, which has just been organized, will have charge of the production and expediting of machinery and equipment purchased by the Emergency Fleet Corporation for ships which are not furnished complete by the shipbuilders. Assistance will also be given to shipbuilders who are having difficulty in getting prompt delivery of equipment they may have ordered direct. It is hoped that maximum results may be obtained from manufacturers, and delays in the delivery of material to ships be eliminated to a large extent.

The Labor Division, room 217, Munsey Building, has general supervision over all questions of furnishing labor, or settling disputes between labor and the Emergency Fleet Corporation.

The Transportation Division, Rapley Building, Washington, has such duties as ordinarily come under the jurisdiction of the traffic department of a large industrial corporation and may be briefly summarized as follows:

Car supply for the transportation of shipbuilding materials, and expediting the movement of that material after it is loaded. Checking of freight bills in which the corporation has an interest. Quotation of freight and express rates for the various departments. Collection of loss and damage claims as well as overcharges. Arranging for railroad, Pullman, and sleeping-car accommodations for employees of the Emergency Fleet Corporation traveling on official business.

The Executive and Administrative Division, 1319 F Street, N. W., is charged with furnishing the personnel and the efficient and economic conduct of the general office business. It also endeavors to establish and maintain close relations and cooperation between the managers of the divisions and heads of departments in order to prevent duplication of work and issuance of conflicting instructions. It also has supervision over the receipt, distribution and dispatch of mail, distributing of information, general files, preparation of statistics and operation of the office buildings.

Some Fundamentals of Rolling Support

By F. W. GURNEY* (*Member of the Society*)

INDIANA SECTION PAPER *Illustrated with* CHARTS

ROLLERS of one crude form or another have been used from time immemorial to facilitate movement, but it is only within very recent years that the support of revolving parts on rolling bearings has been developed to a state that commands the respect of the engineering world. Rolling support of revolving parts, as distinguished from sliding support, is really a recent innovation in mechanical engineering. As a serious engineering proposition its development is coincidental with that of automotive vehicles.

The essential thing accomplished more or less perfectly by ball and roller bearings is the support of moving parts without relative movement between the supporting surfaces in contact. In perfect rolling action there is no sliding contact, only stationary contact. The only movement is where there is no contact. The prime idea of the rolling bearing, stationary contact, is realized through the means of the simplest of mechanical elements, the roller, which gives support to the moving element without the occurrence of any relative movement at the points of support.

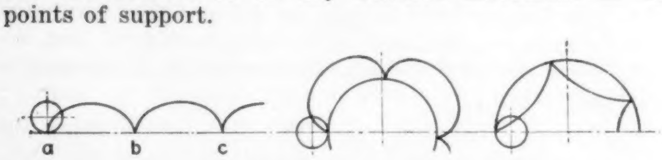


FIG. 1—ILLUSTRATING STATIONARY CONTACT BETWEEN A POINT ON ROLLER SURFACE AND RACEWAY

The fact of stationary contact in rolling support may be graphically shown by tracing the path described by a point in the perimeter of a roller as it rolls over a surface. This is shown in Fig. 1. This point touches the surface on which the roll is rolling at the points *a*, *b*, *c*, coming to a momentary contact and momentary standstill at these points. This imaginary point in a roller describes, when rolling over a flat surface, a cycloidal curve. Such a point on a ball or roller in an ordinary ball or roller bearing describes, with reference to the inner raceway, an epicycloidal curve, and with reference to the outer raceway a hypocycloidal curve. The action of the elements of a ball or roller bearing is exactly similar to that of a planetary gear.

The bare or basic elements of a rolling bearing are the outer and inner race-rings and the rolling elements, which may be either balls or various types of rollers. This elemental bearing is shown by Fig. 2.

PRACTICAL SHORTCOMINGS OF THE IDEAL BEARING

Two things are required of a bearing: to carry the most possible load and to carry it with the least possible resistance. The ideal bearing to realize these fundamental requirements would be made up of purely cylindrical elements, an outer raceway of cylindrical form, an inner cylindrical raceway, and cylindrical rolls just fitting the space between these two races. Such elements assembled in absolutely parallel alignment would form a practically perfect bearing. Such a bearing would carry the maximum of load with the extreme minimum of friction.

The ideal bearing suffers certain handicaps under the limitations of actual conditions. The first of these is that the rollers, no matter how nearly perfect they may be, get out of alignment. A roller out of alignment with its race loses its proper bearing or contact with that race. Its contact with the outer race is at its ends, the straight line of the roller being seated upon a concave line of the outer race. Its contact with the inner race is at its middle, the straight line of the roller seating on a convex surface. The roller thus has to endure a transverse load. It becomes a beam. With one well-known roller bearing this difficulty is frankly recognized and met by making the rollers flexible. Second, a roller that is out of alignment with its race, if not forcibly prevented, rolls in a spiral path on that raceway. The lead angle of this spiral path is the same as the angle of disalignment of the roller. The roller must be forcibly prevented from thus rolling, or obviously the bearing comes apart. If we forcibly prevent this worming along of the rollers on their raceways we thereby force them to slide on their seats by the exact amount that they are prevented from worming or spiralling along. This develops considerable friction between the rolls and the controlling means or cages, and very great friction between the rollers and their raceways, for here they are slipping under their full working load, slipping

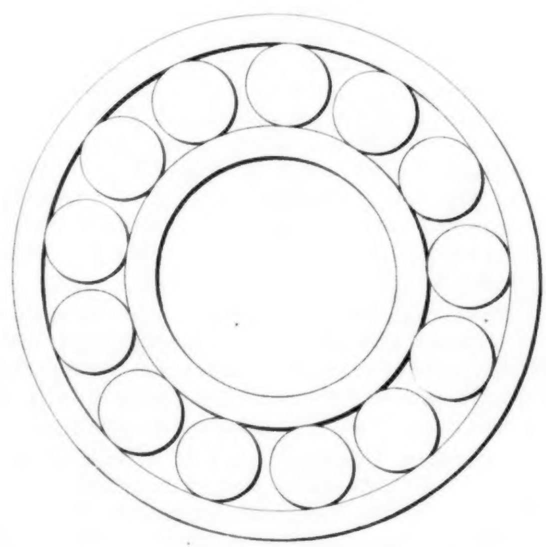


FIG. 2—THE ELEMENTS OF A ROLLING BEARING

under a biting metal-to-metal contact, where no film of oil can possibly be maintained.

This difficulty of the roller type of bearing is inherent and fundamental. It is met, with greater or less success, by the use of "cages." The rollers obviously must have a working clearance with the cages, and this clearance inevitably permits a certain amount of misalignment. Furthermore, the sliding friction of the rollers in their

*Chief Engineer, Gurney Ball Bearing Company.

cages causes wear, permitting increasing misalignment.

The elemental roller bearing fails to meet common requirements in another particular, in that it has no definite axial position, and does not offer positive resistance to end thrust. This fault is met by beads and grooves or shoulders or by changing to a tapered construction. The beads, grooves and shoulders add to the frictional handicap and the tendency toward misalignment. Something of the kind, however, is necessary with taper rollers to prevent their backing out from under the load.

Ball Bearing Construction

From these fundamental difficulties, inherent in any kind of bearing using rolls, whether cylindrical or conical, a possibility of escape is indicated by the use of spherical rollers, or balls. By substituting balls for the cylindrical rollers we escape the troubles due to misalignment, but we still have an inoperative bearing, for there is nothing to prevent these balls from rolling out at the sides. The obvious and simple remedy for that difficulty is to make grooves for the balls. The great difficulty of assembling confronted the early simple ball bearing. There were three solutions: the cutting of gateways into the raceways from the sides, involving a break in the continuity of the race wall; the method of assembly by eccentric displacement, involving reduction in the number of balls; and the method developed by the author, which I might designate as the sidling-in method, involving neither of these sacrifices.

Probably the first observation made to the disparagement of the ball is that it has less load-supporting capacity, for obviously a cylinder bearing throughout its entire length should support a greater load than a ball with contact at only a point.

This is the great indictment brought against the ball bearing. Advocates of the roller bearing seem to regard it as unanswerable.

In the use of a ball in a bearing, the only stress or load that can be put upon it is a simple load exerted radially, or directly toward its center. It cannot be subjected to tensile, transverse, or shearing stress. The only stress it is ever called upon to resist is pure and simple compression.

The steel that is used in the ball and race rings is a special product developed and used for just this particular purpose. It is an alloy which has been found to possess in the highest degree as yet attainable the properties of hardness and toughness desired to withstand the greatest pressures and resist the severest shocks.

The process of ball manufacture has been developed to a point where the day-by-day output of balls runs up into the millions, the balls being true spheres to within a few hundred-thousandths of an inch. The spherical form lends itself to processes, to expedients, in production that are not available in the manufacture of any other form. This is due to its absolute symmetry. It presents its surface to the means of fabrication with absolute uniformity in every possible change of position. In this process the sphere is self-developed and self-maintained, and the spherical form is not contingent upon the accuracy of the producing apparatus.

When we couple with this marvelous precision of form a no less remarkable exactness of size whereby a limit of variation not exceeding one ten-thousandth of an inch is realized in the several balls working together in one bearing some idea is had of the high degree of harmony with which the cooperating parts of the ball bearing work together to realize maximum efficiency and capacity.

It is practically impossible to produce rolls of any style with a precision comparable with that of the steel ball such as a number of ball makers are today turning out in great quantities.

Case of Ball Vs. Roller

"Line contact versus point contact" by no means epitomises the case between the ball and roller bearing. Both terms are unfair and misleading, and neither is applicable without qualification to the type which it is intended to characterize. In the ideal roller bearing we have line contact. In the actual roller bearing we merely approximate line contact, more or less closely. This approximation to the ideal alignment and contact moreover is contingent upon the refinement of the crudest part of the bearing, the cage, in which the commercial exigencies forbid any considerable nicety of fitting.

On the other hand, the so-called point contact in the ball bearing is predicated upon assumptions that are unfair and untenable. Point contact assumes that steel is incompressible, and ignores the immensely important matter of race contour. An incompressible sphere resting upon an incompressible plane surface would have contact at only a point. These hypothetical elements referred to are abstractions having no existence in reality. Under the loads of ordinary ball bearing service there is an appreciable area or spot of contact. The extent of this area depends upon three things: the hardness of the materials, the amount of load or pressure, and the character or shape of the contacting surfaces.

The load that a bearing will safely and successfully carry depends obviously upon the character of the steel, the areas of contact, the character of the surfaces, and the nature of the contact. The safe working load also is affected by the speed, and these various factors are to a greater or less degree interdependent.

Increasing Area of Contact

There are two ways of increasing the available area of contact between a ball and its raceway: increasing the size of the ball and increasing the curvature of the raceway. Take the case of a disk in contact with a straight line. With the same degree of compression the amount of contact between the circle and the base it rests upon will be in direct proportion to the disc diameter. This deals with dimensions in one plane. The sphere deals with dimensions in two planes, and, under the same degree of compression, the contact is in proportion to dimension times dimension, or the square of the diameter.

The areas of contact between two surfaces under the same degree of compression are in inverse proportion to the difference in curvatures of the surfaces. The curvature is the reciprocal of the radius of a curve. When the radius to a curve become infinite the curvature becomes zero. When the difference of curvature of two contacting surfaces becomes zero the curves are the same; they fit. It is perfectly logical by changing the raceway to increase the capacity of the ball bearing, by increasing the race curve to approximate more nearly that of the ball.

For example: Compare the case of a ball on a plane surface with that of the same ball in a groove with a curvature half or a radius twice that of the ball, Fig. 3. In the second case the difference in curvature is one-half that of the first. By changing from the straight race surface to the race groove of one-half the curvature of the ball the contact area and the capacity of the ball are doubled.

The thing which limits the load supporting capacity of the steel in balls and raceways is the compression of the

steel at the places of contact. When the steel fails it simply means that the steel at the place of failure has been stressed beyond the safe limit. The safe limit of stress is very much less than the elastic limit of the steel.

There is a limit to the closeness with which the race curvature may approach the curve of the ball. In large bearings for carrying great loads at slow speeds we make

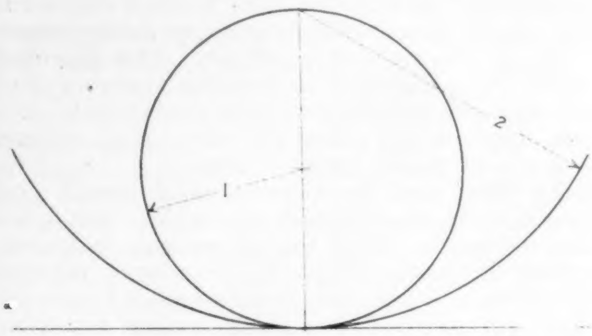


FIG. 3—ILLUSTRATING INCREASE OF CONTACT BY DECREASING RACE RADIUS

the race contour very much closer than in high-speed bearings. In one case the chief consideration is load capacity. In the other, the consideration of load is practically negligible, but the reduction of friction is of supreme importance. In ordinary practice the race curvature may be increased to an extent that will multiply the capacity of the ball many times before we incur objectionable friction. Take for instance a ball in a race groove 3 per cent larger than the ball. Under the ordinary working conditions and at the full rated loads the ball rolls along with a contact arc of about 31 deg. This arc is so close to the race curve it means an exceedingly slight amount of compression, about 0.0003 of the diameter of the ball. Now suppose a shock comes upon the bearing and the load is doubled. We then get an arc of contact of about $37\frac{1}{2}$ deg. and a compression of about 0.00045 of the diameter of the ball, still very small. As loads mount up under shock it requires but exceedingly slight compression to increase contact areas to the degree necessary to sustain their loads. The sides of the raceways are very close to the balls, to lend their support to the balls when the great shocks come. They are available for these emergencies before the steel has suffered harmful compression. The close race curvature spells safety for the bearing.

Close Race Contour

There is yet another way in which I may make more graphic and impressive the meaning of the close race contour. Let us go back to the flat raceway. To increase our area of contact let us decrease the curvature of the ball. We will convert the spherical roller, for the purposes of this comparison, into a barrel-shaped roller, preserving the diameter of the ball (Fig. 4). Let us give to the curve of this barrel-shaped roller such a radius that the difference in curvature between this roller and the flat raceway will be the same as the difference between the ball and a race curve 4 per cent larger. The meaning of this is that a ball bearing in which the balls roll in raceways 4 per cent larger than the balls, is, as regards load-supporting capacity determined by limits of compression, the equivalent of a roller bearing whose rolls are slightly bulging or crowning in the center, the radius of this swell or bulge being 26 times the radius of the ball. One of the very best roller bearings yet developed has adopted practically this expedient, curving slightly the cross-section of the outer raceway instead of that of the roller.

The ball bearing made with close race contour is in effect a roller bearing. In it is realized ample areas of contact which the advocates of the roller bearing have been claiming as their particular possession.

By the application of this practice to ball bearing construction the ball bearing does not lose its unquestioned position as the pre-eminent anti-friction bearing. But by this means it is securely established as the great capacity bearing adequate to carry, with the minimum of resistance, practically any loads that may be desired. Ball bearings are being applied with the most gratifying success in positions where the severity of the service makes roller bearings out of the question, and by their use results are realized that had never been attainable with plain bearings. On the other hand, it has frequently been found that under such exceptional loads the friction developed in roller bearings is actually greater than that with plain bearings. This is explained by the fact that with the roller an unpreventable slippage is incurred, which, under the intense pressures involved with metal-to-metal contact and no possible oil film, results in the excessive friction.

I am a user and an advocate of the roller bearing. There are on the market roller bearings of unquestionable

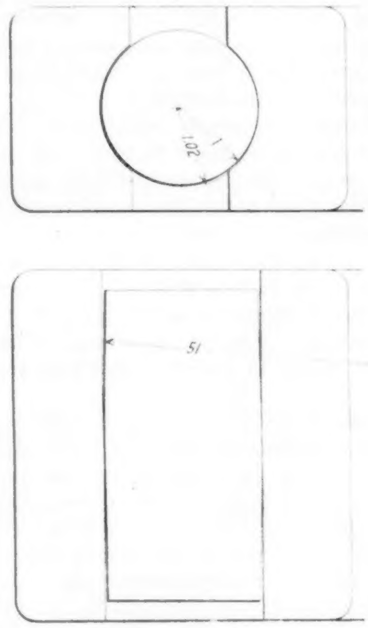


FIG. 4—COMPARISON OF BARREL-SHAPED ROLLER TO BALL IN CLOSE RACE

quality and there is a distinctly legitimate field for such bearings. I wish to offer the opinion, however, that in the great majority of cases the requirements may better be taken care of with ball bearings than with roller bearings.

THE DISCUSSION

G. W. SMITH, JR.:—The question of bearing design is usually a compromise and the best bearing may be one or the other, depending upon the inherent capacity. For instance, it is a question whether or not roller bearings are not preferable on account of their smaller outside diameter. In certain cases the rear axle design almost determines the weight of the assembled axle, so the question of limiting conditions often decides which bearing is the better.

F. W. GURNEY:—Outside diameter limitations sometimes make it impossible to use ball bearings of adequate capacity. One point little recognized heretofore by most manufacturers is that by the application of close race contour those limitations may usually be made less severe and the desired capacity may be gotten without increasing the diameter.

F. E. MOSKOVICS:—I would like Mr. Gurney to tell what he has found out regarding relative end thrust and radial loads.

F. W. GURNEY:—In the roller bearing, end thrust is taken care of by taper construction, and by shoulders, but not as efficiently as by a ball bearing, with a proper inclination of the axis of rotation of the ball and the contact angle of the ball with its raceway. In this way there is no difficulty in taking care of end thrust, and ball bearings operate with greater efficiency than roller bearings.

With a full complement of balls in a raceway as deep as we ever use to carry a radial load, the load on all these bearings is practically never great enough to bring contact of the ball up to the edge of that raceway.

C. S. RICKER:—That is about 15 deg. on either side of the plane of the bearings?

F. W. GURNEY:—On one side it comes up more than 15 deg. It must be remembered the angles I give in my paper are angles that are very seldom realized. They are the very extremes. The arc of contact that obtains under ordinary practice is probably not more than 15 or at most 20 deg. The large angles of contact are only instantaneous, taking care of shocks. The ball ordinarily runs in a much narrower path.

C. S. CRAWFORD:—I would like Mr. Gurney to compare ball bearings to taper roller bearings for a hub of the same size; in other words, interchangeable bearings.

F. W. GURNEY:—Two prominent concerns conducted some experiments with the Gurney "radio-thrust" bearings in front wheels with a prominent taper roller bearing. The bearings were of the same diameter, and either bearing would go into the same hub. They equipped a number of cars with roller bearings on one side and ball bearings on the other and took them on a long endurance test. The chief engineer of one of these concerns told me that the average life of the ball bearing in that test was 75 per cent greater than that of the roller bearing.

Bearing Lubrication

F. E. MOSKOVICS:—I would like to obtain Mr. Gurney's theory on lubricating bearings.

F. W. GURNEY:—If ball or roller bearings could work perfectly there would be no need of lubricants, but there is no such thing as perfection in any of this work. The lubricant is not so important as might be imagined. Ball bearings generally run cooler dry than with a lubricant. However, lubrication is an exceedingly desirable thing in a ball bearing. We had a case of a ball bearing installation which ran six months without any lubricant in it, and nobody knew the difference. It had been running at 3000 or 4000 revolutions per minute for six months in daily service. The bearing was somewhat worn but not so much as to attract attention. It is necessary to lubricate between the separator and the balls. A film of oil does get between the sliding edges of the balls where the pressure is less intense. Where there is no slippage, there is no need of a lubricant.

Limiting Speeds

D. L. GALLUP:—Is there any condition of speed and load under which ball bearings cannot be used?

F. W. GURNEY:—Certainly, but speeds that are impossible with any other bearings can be reached with ball bearings.

D. L. GALLUP:—The other day I came across an instance of where a manufacturer changed to plain bearings on account of running at high speed. I wondered if it was a mistake on his part.

F. W. GURNEY:—They must have been improperly installed. Brown & Sharpe use ball bearings running at 40,000 r.p.m. and doing good work. They found they could not attain this speed on plain bearings.

F. E. MOSKOVICS:—What is a fair speed for the balls?

F. W. GURNEY:—The ball speed in those bearings is about 4200 r.p.m. The balls in those bearings are ½ in. diameter. The bearing ran cold.

G. W. SMITH, JR.:—It has always been my contention that we can make a cheap roller bearing and get away with it fairly well, but that we cannot make a cheap ball bearing and get away with it.

F. W. GURNEY:—I think practically Mr. Smith is right. I know there are some cheap cup and cone bearings which have a real field. But the modern annular ball bearing has got to be made well, whereas a roller bearing can be made cheaply. In fact, that is one of the principal fields for the roller bearing.

Graphite Lubrication

H. G. McCOMB:—Manufacturers universally frown upon graphite grease. I would like that opinion confirmed, if it is true.

F. W. GURNEY:—We have not experimented a great deal with the use of graphite grease in ball bearings. The Acheson people claim that it is a success in ball bearings. As to the validity of that claim I cannot say. It is important to use a lubricant that is free from any element that will corrode the surface. One point which too few people appreciate is the great importance of keeping bearings clean. There is nothing quite so destructive as dirt, and dirt does not necessarily come from the outside. There is apt to be considerable abrasion under the bearing, a wearing off of the metal in very minute particles, if there is any vibration of the bearings upon the seat. These particles very soon become oxidized, and oxide of iron in the lubricant is the result. It is a beautiful abrasive, but a very poor lubricant. When the oil becomes red, it should be removed at the first possible moment. Sometimes the wear from the gears produces oxide of iron, which very rapidly destroys the bearings. Bearings are credited with many faults that are not theirs. Too much lubricant should be avoided in high-speed bearings. In the case of very high-speed bearings, the lubricant has to be very light oil, and there should be very little of it.

G. W. SMITH, JR.:—I would like Mr. Gurney's views regarding the commercial efficiency of sub-oiling bearings for live shaft requirements.

F. W. GURNEY:—Sub-oiling adds greatly to the length of life if it ensures the shaft running on a film of oil with no metal-to metal contact. It takes slightly more power to run it than with a good ball bearing, but not much more than with an ordinary roller bearing. The great gain in the use of ball bearings in cases of that kind is not so much in saving of power as in saving trouble.

Periodically without fail we must go over ordinary boxes to see that they are kept supplied with lubricant. That is not necessary in the case of ball bearings, which can be oiled every six months or once a year or even not that often, and still have no trouble. A well-designed ball-bearing hanger will contain lubricant enough for over a year, which is a great convenience.

Vol. II March, 1918 No. 3

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Present Requirements of the Automobile User

By J. EDWARD SCHIPPER* (*Member of the Society*) CLEVELAND SECTION PAPER

THE war is like a gigantic metal whirlpool into which metals are drawn from all over the world to find their way into the guns and into the thousands of other war instruments which are necessary in the carrying out of a modern battle.

Many of these metals and many of the other materials used in the construction of automobiles are used at the front, and many of the other metals and other materials which are used in the automobile are necessary to the factory which is making munitions for the front, and so the question of materials becomes one of prime importance in the automobile of today.

This may seem like a matter entirely for the car manufacturer, and yet it has as much to do with the consumer as with the maker of the car. In spite of the fact that cars are increasing in price almost from month to month, the demands of the user for performance are also increasing from month to month. While the average price of automobiles has gone up several hundred dollars, if we leave out of consideration for the moment the very lowest price cars, the average price that the user wants to pay has not gone up nearly as much as the price, and therefore we see performance, which was formerly expected only in the higher priced cars, demanded as a matter of course from cars which at the present time do not cost nearly as much.

No one knows better than the automobile manufacturer that the car buyer wants performance. The carbureter manufacturer knows that the public is demanding that he produce an instrument capable of throttling to speeds hardly in excess of 2 m.p.h. and upon application of the throttle of picking up rapidly and surely to speeds in excess of 50 m.p.h. on fuels which are forever going down in quality and volatility.

What does the average user demand? He wants a car that does not cost him too much, in the first place; he wants one that will be in the service station for the minimum amount of time. It is a matter of pride with every user that his car is dependable, and it is a matter of necessity with most users that the car will be able to perform more than 300 days a year without a falter. If we took an average of all the users in the country, we would probably find that there is a demand for 15 miles to the gallon of gasoline; there is a demand for quick acceleration, good hill climbing, easy gear shifting, comfort in the seats and springs, accessibility for small adjustments and repairs, a minimum, or rather an absence of rattle, and when it comes to tires, anything short of 8000 miles is always occasion for a fit of peevishness.

Size and Acceleration Demanded

The American public demands the appearance of great size in its cars. The largest car selling for a given price will carry large sales, simply owing to its size. Coupled with this demand for great size, the American public also demands acceleration. Size means weight and weight certainly operates against acceleration to such an extent that the torque requirements of the engine must be increased greatly to give the pickup desired with the large car.

In Europe there are cars which, by a scientific use of the wheelbase, give all the necessary room at a greatly reduced weight, and consequently can supply all the acceleration demanded with an engine of greatly decreased developed horsepower. The fact that the car weight is less allows the engine bearings and all other parts to be reduced accordingly and at the same time have factors of safety which are largely those used in average American practice, giving a greater endurance and a smaller service factor than can be expected from the large, heavy, high-powered design which engineers have been forced into much against their will.

War time is a time for economy and efficiency; therefore, let us appeal for a car design which is efficient and economical. It is exactly what the public wants, but owing to the education given them through unhappily worded advertisements and by other means, the public believes that its demands are met in proportion with the size of the car. Tire economy and miles per gallon of gasoline and other desirable requirements have been sacrificed because it is believed that acceleration and comfort in riding can be secured only with the car of long wheelbase. As a matter of fact, careful design, coupled with compactness in engine units, will allow several inches to be taken from the wheelbase of the car without any sacrifice of room, without a great loss in riding comfort, if any, and at the same time with a gain in materials, a saving in weight, a saving in tires, a saving in gasoline, a saving in space required for parking, and a saving in every direction which can be thought of. It costs less to build a shorter car, and this money could either be taken from the price of the car, which would certainly be another factor in what the user is demanding, or it could be used in refining the design, probably with the result of even greater lightness and better upholstery, better painting, and better trimming; all tending to make the result a high-class car throughout.

Trend Toward Smaller Cars

High-priced cars in this country have nearly always been big cars, owing to the necessity for catering to the taste for size, and yet the very trend of public demand shows that exactly what it wants can be met in a medium-priced small-size car which incorporates all the beauty of design to be found in the highest priced products, and all the excellent materials which are used in cars which today are only sold in long wheelbase.

Engine size has nothing to do with performance. Torque-weight ratio is the governing factor in acceleration and hill climbing, the two greatest demands made

*Technical Editor, Class Journal Company.

by car buyers in this country. The demand for reserve torque will probably exist for years to come, and the value of horsepower is something which has been greatly exaggerated by means of the literature of engine and car manufacturers. The words, "high power," are fascinating to the layman's mind, and he has been led to believe that if he has a powerplant capable of a high maximum output under his hood, he has an engine which will enable him to run away from other cars with a powerplant not capable of developing such high output. This, of course, in the face of real analysis is untrue, because the high horsepower may not be reached until such a high number of revolutions per minute that the car speed would be prohibitive under ordinary gear ratio conditions.

All the performance desired in a five-passenger automobile can be secured with an engine under 200 cu. in. piston displacement. All the acceleration wanted and all the hill-climbing ability would be incorporated in such a car. The ratio of engine torque to weight could be made very high in such a car at the speed at which such a ratio is most desired, and if an engineer were told to get out a five-passenger car in which all the performance demanded is incorporated, together with an economic use of materials and an economic maintenance factor maintained, he would be wrong to go much above the 200 cu. in. limit. The idea that a perfect-riding car is one of infinite weight should not be the goal.

Pounds per Passenger Too High

Weight of car per pound of passenger weight is too high in America. The tendency toward long wheelbase and big engines is responsible. A five-passenger car should not weigh more than 3 lb. per pound of passenger weight if it is to be considered a truly economical design. With a designed load of 750 lb., a 2250-lb. car would be about right.

If this economy in material and maintenance were carried out there would be much less talk regarding material shortages, and this vital means of transportation would not be threatened to be put in the class of non-essential industries. It is impossible to picture the farming districts of America without automobiles. It would set the country back like nothing else in the realm of imagination.

This presents the picture from one side. We all know what the public demands because we know exactly what we like ourselves in a car. We like to step into a roomy, comfortable front compartment, into which we do not have to squeeze in order to seat ourselves behind the steering wheel. We are always pleased when our first glance tells us that the control members can be readily seen and readily reached. We want the engine to start almost on the first touch of the starting button; we like the starting pedal to engage with little effort, with the engine running smoothly and quietly; we want a clutch pedal which is depressed by very light touch of the foot and which when engaging gives a smooth pick-up without unnecessary slipping and without excessive grabbing. In shifting gears, the clutch should release instantaneously and positively, so that there is no drag in the gears, and the gear lever itself should throw into mesh with a minimum movement and with a minimum amount of reach required to place the hand upon the shifter lever. In picking up, the operator should be able to depress the throttle almost as quickly as possible without creating undesirable conditions of knocking, choking, spitting back, or laboring of the engine. In other words, carburetion, gear reduction, and engine capacity and torque output should be so attuned that a smooth accelerative ability is given. Here, of course, lightness again enters.

Cold-Starting Problem

To the list of requirements given above must be added that of starting rapidly on a cold morning. This is the most pertinent point of all at the present time.

All the hot-spot intakes and exhaust jacketed carbureters in the world will not do one thing toward making the car easier to start. The carbureter manufacturers have provided us with very efficient chokes; even at the speed attained by the average starting motor on a cold morning these chokes are capable of shooting into the cylinders a supply of raw gasoline which would go a long ways in operating a dry cleaning establishment. Sometimes some of this raw liquid is ignited during the first three or four minutes of cranking, but often the motorist helps the situation along by distributing ½ pint more of gasoline between the four, six, eight, or twelve cylinders. This joins the supply which the efficient choke has put into the combustion space, and ignition starts; only, however, after a liberal supply of the raw fuel has leaked its way past the piston rings and gone down into the crankcase.

If the car starts in 30 seconds the user is fairly well satisfied. He does not think, however, of all the gasoline that can be drawn into the cylinders and leak past the piston rings in the space of 30 seconds, he does not consider the fact that his lubricating film has been destroyed to a large extent by this gasoline, and he does not stop to consider how much the supply of lubricant in the crankcase has been deteriorated owing to dilution of the oil by the heavier constituents of the gasoline.

This situation is probably the most serious one which confronts the designer today. The automobile user is demanding service, and he will not get good service from an engine which is being treated in this manner. The first few minutes of running with an engine in this condition work considerable damage to that powerplant, and the problem must be met quickly or else a great amount of damage is going to done during this winter to cars which are kept in unheated garages, as most are.

In these days when high prices of labor and material are forcing the price of cars upward, something must be done to meet the cold-starting situation. A heating coil in the float chamber or other gasoline chamber, a water-heating system connected with the radiator, or some other method which is equally effective, must protect the owner from the consequences of crankcase dilution. The average owner knows that it requires a pint or more of gasoline to warm up his engine on a cold morning. He knows that he is not burning this pint of gasoline, and all of it is not going out of the exhaust; the remainder forces its way into the crankcase, and cars fitted to combat this trouble will go a long way toward meeting one of the biggest demands made by car users.

Preheating the Air

The heated intake has been studied so carefully by all manufacturers that it is useless to dwell upon it. However, there are a great many manifolds which are erring on the side of too much heat rather than too little. It is practically impossible to meet the extreme ranges of temperature conditions—100 deg. or more in most of the cities along our temperate belt—without some sort of adjustment. The air is always preheated to some extent and probably the means of adjustment to meet the out-

side temperature conditions is most rapidly effected by varying the amount of heat which is imparted to the initial air before it enters the carbureter. Too much heat makes the engine unsatisfactory, due, of course, to its reduction in volumetric efficiency, but the proper amount of heat, in spite of the expansion of the intake gases, will often result in an improved torque curve.

Economy and Appearance Demanded

It is a noticeable fact that this year's car users are demanding gasoline economy more than ever, and vigorous activities can be noted on the part of carbureter manufacturers to supply this demand.

The carbureter, however, is not the only factor in economy. Lightness is a paramount necessity. Lightness does not mean alone the reduction of weight by scientific design of parts, but it is possible to gain a far greater amount of weight by a scientific use of wheelbase length. In this country we have been wasteful of wheelbase. We have secured a minimum of passenger space with a maximum length of car. It has been possible in Europe, due to the use of shorter engines, shorter hoods, and the more scientific location of parts, to get much more room on a given length of car, with the result that the car weight per passenger has been very much reduced. Scientific designing from one end to the other would make possible a great economy in materials with very little sacrifice in performance; in fact, there need be no sacrifice but an actual gain in the way the car operates.

The rear axle gears and in fact the entire transmission mechanism should be quiet and sturdy, the propeller shaft should not whip, and none of the parts beneath the chassis should be so filled with grease cups that the user of the car is fortunate, indeed, if he finds 25 per cent of them on his first greasy search beneath the chassis.

The appearance of the car should please the eye. Exterior appearance is a matter of choice, and like a great many things which are changed from season to season, it is impossible to lay down any rule. Present-day style calls for long, straight lines without sharp breaks from radiator cap to the end of the tonneau. Another year this might be different. Nevertheless, the car should conform to the dictates of the moment. The upholstery should be good, and here it may be said that some of the latest of imitation leathers are rendering excellent service and are doing better in fact than poorer grades of genuine leather.

The top should be designed to be quickly put in place and the side curtains should permit of ready view on all sides of the car. Some of the side curtains, with their small lights, shutting off the view of the driver, are a positive menace in city driving. The windshield should be drip-proof and have the ventilating feature. The engineer must supply by scientific design what the public demands in the face of the fact that he is now under limitations of material which did not hinder him a year ago.

THE DISCUSSION

A MEMBER:—What has Mr. Schipper found regarding the sentiment for permanent tops or enclosed bodies—are they increasing or decreasing?

J. E. SCHIPPER:—I believe the use of the permanent top is increasing, and by that I mean a top that *is* permanent. I believe that the winter top, or the one that is put on in place of the summer top, is decreasing. I think the convertible car, in which the sides but not the pillars are removable, is increasing, and construction is materially improving on that type. The pillars are being made more rigid and they are fastened in place more substantially. The car will remain tighter for a longer time than used to be the case. The tendency to rattle was so great in these convertible sedan types that it threatened to kill the design, but improvements have come along so fast that I believe they are on the increase.

J. A. WILLIAMS:—I do not believe that they have yet found an all-weather car. As yet there are no means of supporting a heavy, bulky top with the satisfaction of a solid brougham sedan that was first brought on the market, and I believe the ultimate car will answer all those purposes. The doors will probably have flappers, but I can't believe that the ultimate car will have detachable pillars, because they are inconvenient to handle.

W. R. STRICKLAND:—The feature of removable pillars is handled differently by different owners. In some parts of the country they have the pillars out without any occasion to put them in quickly. In other parts of the country where the weather is unsettled the removable pillar feature has helped the salesman to satisfy the buyer. I believe the permanent pillar is an improvement from a body standpoint.

A MEMBER:—It has always been my idea that the ultimate enclosed car will have no pillars in it. It seems to me that a car can be constructed that will have the glass in the front door fold in and disappear in the front door, and the glass in the quarters between the rear door and the front door fold in with the rear door, and also the rear quarter glass fold in and fold around directly and disappear behind the seat, and right at the present time I am trying to "dope out" that proposition. I really think removable pillars are very objectionable. There is rattle and strain on all of the pillars; in spite of the precautions we may take in tightening them and putting in bumpers it is bound to develop in time. I do think the one-man top has not been a success, and that the ultimate stationary top will be made with no pillars but with glass that will disappear.

Body Construction

J. A. WILLIAMS:—Speaking of the ultimate car, the percentage of sales is very small on enclosed bodies. Hardly 10 per cent of the cars are driven today with the top down at all. Top materials cannot be folded up and down continually without cracking and it appears very evident that tops are going to be permanent ones.

A MEMBER:—The ultimate car is not going to have a folding top. Buyers are going to demand better protection from the weather. The body designs have been changed from year to year; the engineers keep improving the chassis and still we go on with the same old top. If we can create a neat appearing top that does not have to come down, I think it will appeal to the average car buyer.

W. R. STRICKLAND:—In Mr. Schipper's paper a good deal was said about economy. Folding doors and windows increase the weight tremendously. Most of the features mentioned increase the wheelbase. We are trying to keep the weight down and keep the economy good. Dealers, I think, are coming to the conclusion that these heavy cars are going to decrease in popularity owing to the weight. People do not want to go touring with these heavy cars. It means too much wear and tear on the engine and tires and too much gasoline.

J. A. WILLIAMS:—That is a very excellent point, but the most vital economy has been overlooked and that is the initial cost as compared with that of the present touring car.

A MEMBER:—I heard Mr. Schipper say carbureter makers have endeavored to increase the velocity in their carbureters, thereby raising the volumetric efficiency at lower speeds, which is quite right. From my experience one is not satisfied alone with quicker acceleration and good torque and good performance of car at low speeds. In addition very good high speed performance is desired. This problem has not been solved yet, and becomes harder every day as the fuel we are obliged to use becomes of poorer quality.

Multi-Stage Carbureters

W. R. STRICKLAND:—Do you suggest the two, three and four-stage carbureters?

A MEMBER:—The two, three or four-stage carbureter will not handle the proposition because the velocity will not govern the volumetric efficiency. With a manifold that is in keeping with the two-stage carbureter, if this manifolding is of such small size to correspond properly to the first stage, the volumetric efficiency of the same engine in the second stage comes into consideration. It will be very low because the manifolding is too low. I have made some experiments in the last year, and I have found that maximum torque can be obtained on an engine with very large valves with the first stage carbureter and maximum horsepower can be obtained.

Manifolding will not take care of the gasoline we have to contend with to-day. I do not agree that a thorough atomization is of any value whatsoever. If heat is not applied to the products of atomization it does no good at all with the present grade of gasoline. The opinion of engineers as to heat applied at a certain spot is quite varied. We have to figure a theoretical loss of volumetric efficiency as soon as we apply heat to the gasoline, but this small amount can be neglected if we will figure how much actual thermal efficiency we gain by having to deal with a gas instead of with a fluid.

J. E. SCHIPPER:—I saw lately some extensive experiments carried out by the Holley Carbureter Co. on the Ford tractor. It was found possible to vaporize kerosene, get it in the form of gas, and then carry that gas even with a drop of temperature through several inches of the manifolding without recondensation. If that can be done with kerosene it can be done with gasoline. I believe Mr. Horning once mentioned the same thing in his experience. If the kerosene is put in the vaporous condition it can be carried over the long distance without condensation taking place, as verified on the Ford tractor. Their first design had the shortest possible intake, because they believed that if they lengthened the intake they would get condensation, but they found out that the longer the intake, without limits, the higher the performance on the block will be.

Referring to engine performance and economy, one of the reasons our engines are not more economical is too high piston displacement. In a five-passenger car this should not go above 200 cu. in., and it is my firm belief that the tendency is toward decreasing piston displacement. On the Indianapolis Speedway a car of that order gave a performance that startled the public. That was with a little Peugeot, and if it can be done in racing cars it surely can be done in passenger cars.

Kerosene as an Anti-Freeze

I want to mention using kerosene as an anti-freeze. I know of several factories using it as an anti-freeze and with a pump cooling system and keeping the system full, it works out all right. With a tubular radiator it works out very well, that is, on the cars of the Ford and Dodge type, but on cars with the thermosyphon system and cellular radiator such as the Hupmobile, the kerosene does not seem to work well; the explanation given is that the pressure due to the thermosyphon is too low. The prices of alcohol and glycerin are so high now that I really think the engineers in the industry ought to inform the car owners immediately. A good many have gone to calcium chloride sold under different names and are troubled with short circuited ignition systems.

W. R. STRICKLAND:—We must have some members who have tried kerosene. I know many owners that are using kerosene and have not heard any arguments against it.

A MEMBER:—Four years ago we had a Chalmers 36 and we used kerosene all one winter. That had a pump circulation and we had very good success with it.

J. E. SCHIPPER:—Testers around the Chalmers factory are using it in factory cars.

W. R. STRICKLAND:—I think the greatest objection would be the odor of the kerosene. I never thought of using it before, but in real cold weather it would save considerable money.

A MEMBER:—I have never used kerosene, but should imagine that one of the chief difficulties would be in keeping it thoroughly mixed with water.

J. E. SCHIPPER:—Do not use any water—use all kerosene. The specific heat of kerosene, I think, is about 0.7 of that of water, so that the engine will be kept running at a high temperature with the same amount of radiator service, and for that reason the temperature is going to be higher. For every pound of kerosene circulated, instead of carrying off a similar amount of heat from the cylinder walls, 0.7 of the amount that would be carried off by water is removed.

A MEMBER:—A compound that is soluble in the kerosene might be mixed with it, mixing enough to make it the same density as the water.

A MEMBER:—A friend who had filled his radiator with kerosene said he had run his car up to 40 miles an hour and had no trouble with kerosene except that it melted out the rubber hose. If it got very hot kerosene might cause trouble with vaporization.

J. E. SCHIPPER:—We can count on losing a set of hose a season with kerosene, nevertheless the money saved would replace the hose many times. It would not do to use kerosene at temperatures over 20 deg. fahr.

Motor Trucks in War and Commercial Service

By G. W. SMITH* (*Member of the Society*)

MID-WEST SECTION PAPER

THE subject of military trucks has been more or less divided in discussion into two general groups dealing with operation on the Mexican Border and with operation in the war area of France. A summary, representing what may be called an average opinion of the truck engineering profession, is given below.

Changes desirable for service similar to punitive expedition in Mexico:

1. Great increase in cooling area of radiators, probably 50 to 75 per cent.
2. An increase in low-gear ability by increasing total gear ratio. This positively indicates a 4-speed transmission with a low-gear ratio of not over 20 per cent.
3. An increase in high-gear ability by means of an increase in piston displacement. This value varies from 33 to 37 lb. gross weight per cu. in. of piston displacement.

In addition to the requirements as given above it is necessary to design the suspension of the various units with the greatest care in order that distortions cannot cramp or bind the various joints and moving connections. Many details of design need improvement and particular attention must be given to the lubrication of the various bearing points.

Changes Desirable for European Service

For service similar to that of the Allied armies in France the following is indicated:

1. Improved design of detail and greater refinement in workmanship, particularly with reference to American trucks.
2. Somewhat more liberal dimensions of the various parts.
3. Increased radiation in some cases.
4. Better design of engines, incorporating such features as full force lubrication, improved carburetion, more liberal bearings, crankshafts, etc.
5. Improvements in the design of clutch and transmission units to facilitate repair and preserve the alignment of the various parts.

The foregoing covers, of course, the deficiencies of commercial trucks and does not sum up their virtues.

The manufacturer of motor trucks has to contend with some very adverse conditions in comparison with other industries. The buyer in most instances is a good business man but does not have the experience or training to properly judge the merits of the machine offered. In fact, a considerable part of the merchandising end of the motor-truck industry is deficient in the elements that make for satisfaction to the buyer and seller.

The requirements of the Mexican service were extraordinary. The railroads, which should have carried the supplies, were in the hands of the "de facto" Mexican government, and, for reasons best known to our government, were not available for our service. This meant that trucks would of necessity be used where there were no roads and not a single favorable condition.

It is hardly conceivable that such a situation could arise. The conditions were neither those of peace or war, either one of which would have made it unnecessary to use trucks as they were employed. In case of war, railroads would have been seized and supply trucks could have operated from bases to supply points chosen with much more freedom and care as to road conditions. In case of peace, trucks could not hope to compete with railroads for the distances that were involved unless suitable roads were provided.

Adverse Conditions on the Mexican Border

As to the maintenance of the trucks it is absurd to expect to provide anything that will show a reasonable operating cost under the conditions met with. The entire truck from tail lamp to front bumper was covered with a fine grit of first-class abrasive properties to a depth varying from one-eighth of an inch to one-half inch. Any joint sufficiently close to keep out this abrasive material would be entirely too close for lubrication requirements. The average truck stood up well considering that it was not intended to perform the service to which it was applied.

Another thing which should be considered is the personnel of the operators on the Mexican border. No criticism of the United States Army is intended, as the American people themselves and not their Army officers are responsible for the condition of unpreparedness which arose at that time. It can be stated as a general proposition that the average truck driver was considerably under the desirable standard. Even the men sent from the factories were not above reproach, as many of them were hastily chosen and had little actual experience.

As a result, with few exceptions no attempt was made to operate trucks at governed speeds. This statement must be modified somewhat on account of the governor mechanism going wrong owing to deficiencies in design. In the main, the general statement is true.

Another difficulty was the absence of any suitable place to make repairs. Not until nearly the end of the expedition were proper conditions obtained. It was quite common for repairs to be made on the engine and other units of the trucks amid a perfect cloud of sand and fine dust.

Ordnance Organization

These conditions were observed by the officers of our Army and we are happy to say that they will never again be duplicated. It would be difficult to accurately appraise the various operating organizations which have been brought into existence since the declaration of war. The work of the Ordnance Department is better known to the author than that of other departments, so his remarks will be confined thereto.

Many men have been chosen as commissioned officers to have charge of the operation of the motor equipment. These men have been selected with reference to their technical knowledge and familiarity with motor vehicles. It is safe to say that they rank as near 100 per cent as is humanly possible. Schools are established at many points and the various vehicles are being studied from

*Assistant Chief Engineer, Nash Motors Company.

all points of view. It can be taken as a foregone conclusion that we will be proud of these men when they get over there and demonstrate the real ability that is in them.

Truck Drivers

It has been stated that the drivers of trucks will be chosen from the National Army and possibly recruited by volunteers. No accurate information seems to be available at this time. It is earnestly hoped, however, that the selection of these men will be carefully considered. As a general rule few men who have driven passenger cars are suitable as first-class truck drivers. The truck driver should be strong, although not necessarily large, and should be possessed of sufficient judgment to recognize when trucks may be operated at full speed advantageously and when to slow down for rough going or over a chuck hole in the road which will jar the truck from end to end unless negotiated with care. Some of the best drivers in the commercial truck field are men who have been teamsters, and have been retained to operate the new trucks when they have superseded the horse-drawn vehicles. The operators should also be required to inspect and lubricate the vehicles as frequently as operating conditions will allow. Once daily, for many of the units, is none too often when it is considered that labor will be plentiful. Any reasonable attention will certainly be repaid many fold.

Large Pneumatic Tires

An important recent development is the use of large pneumatic tires in sizes as large as 10 in. section, and it is stated that sections of 15 in. are commercially possible. The use of pneumatic tires does not mean simply putting them on existing chassis but will demand larger engines and higher gear ratios to keep the engine speed at a normal value. It will also be possible to reduce the dead weight ratio to the pay load and greatly increase the efficiency of operation.

The heavy-duty low-speed truck may also extend the operating limits of trucks to territories now considered impossible. Road conditions involving deep mud and sand where the tractive resistance may be around 500 pounds to the ton may be dealt with successfully. On the other hand it is extremely doubtful if sufficient power can be utilized by a rear-drive vehicle to pay for the greatly increased cost of construction and operation that of necessity goes with more power. The maintenance problem is by no means solved, as it must be remembered that any increase in torque must be taken care of by a corresponding increase in all the driving and supporting mechanism. The more powerful the vehicle, the more ability it has to destroy itself. Only a few years ago the automobile had arrived at a state of development where it would operate with fair satisfaction and economy. Immediately there arose a demand for more power. The power was accordingly forthcoming and almost immediately the cry went up that the power was all right but the chassis was inadequate. The next year the chassis was strengthened, with an increase in weight and a decrease in power. This alternate change continued until the advent of the multi-cylinder engine, when the pressure was somewhat relieved. The simile between past history and the subject under consideration is possibly greater than is generally appreciated.

Possibly the most satisfactory application of the increase in power is to drive on all four wheels. This can be accomplished with a relatively small increase in weight and increases the ability of the vehicle to an extent that eclipses anything that can be hoped for in two-wheel driven vehicles. The effect is greatly augmented by the use of some form of friction differential. There is no question that the conventional truck can use a large amount of power when operated on dry, hard roads, but when sand roads and mud are to be negotiated the increased power is of little use, as the wheels easily embed themselves and lack ability to drive the front wheels forward or even to get themselves out of the hole.

It is common to see trucks of merely nominal power spinning their drive wheels in deep sand or mud. In such cases about the only hope is to hitch onto another truck or by means of a number of levers, jacks and dry materials thrown under the wheels to painfully creep out onto more favorable going. All this takes time and means more or less damage to the tires and driving parts of the machine.

As time goes on road conditions improve, grades are reduced and it becomes constantly more profitable to operate trucks. It is possible that some kind of finality may be achieved in the design of trucks. Until such time standardization should be undertaken with extreme caution. Any general standardization should be undertaken only as an extreme military necessity and not as a proposition likely to do good to the industry.

This remark does not apply to the various matters of detail such as spark-plugs, magneto bases, screw and bolt sizes, or even to the question of standardizing such things as wheel gages. The last subject mentioned should be handled rather gingerly, perhaps, in view of the inconvenience caused by the standard gage of railroads. It is general knowledge that the 56½-in. gage was adopted as an inheritance from horse wagon practice in the swaddling days of the railroads. Endless inconvenience in the design of locomotives and cars by reason of the limitations of space between wheels is now the lot of the locomotive builder.

In summing up it would appear wrong to hastily discard any of the well-balanced vehicles now being furnished to commerce and substitute a new and comparatively untried combination of weight ratio to load and power. The only hope of advantage for such change would be an extremely doubtful chance of securing greater durability.

Economy with Good Roads

Economy in transportation seems to lie in a very different direction. Good roads are coming almost automatically and with them will come higher speeds. This brings us to the pneumatic tire. With the pneumatic tire will come larger ground contact and more "buoyancy," if the term can be permitted. This so-called buoyancy will make it possible to negotiate soft going without sinking in so deeply as with narrow solid tires. The average truck operates less than 10 per cent of its total working time on bad road conditions, hence the latter design would offer more likelihood of success.

The development of the future truck must be the result of a natural evolution and not an arbitrary selection by a limited number of engineers with no positive knowledge of future events.

Efficiency in Factory Reproduction

By Francis A. Carlisle* (*Non-member*)

Mid-West Section Paper

THIS has been heralded as an age of invention and mechanical awakening, and while this is not to be minimized, to my mind the development of efficiency in factory reproduction is more responsible for our present state of advancement than all the inventions considered together. Nay, more than that, this insistent demand for standardized production has been responsible for a very large proportion of these very inventions.

Probably the manufacture of typewriting machines gave the modern movement its present impetus, though previous to that time the demand was making itself felt among many of the growing manufacturing interests. The phenomenal growth of automobile manufacturing, more than any other industry, has brought the movement to its present zenith.

To be truly effective, efficiency must go to the sources of production. Hence, as never before, specifications are receiving the closest scrutiny of experts. When the automobile manufacturer decides to bring forth a new creation his engineers must consider what it will mean to the factory, and the location of every hole and piece of material must be weighed as affecting repairs, replacements, and improvements on machines previously produced.

Next the equipment of the factory in machines and personnel, and even physical location, must be carefully considered, or it may be found that when manufacturing has commenced prohibitive investments in special machinery and factory layout will be encountered. The question of special machinery, practically worthless for any other than its intended use, is very serious, and, in view of the rapidity with which obsolescence retires machinery costing many thousands of dollars, essentially as good as new, is not by any means an insignificant problem.

To these problems the engineer must also assume the rôle of the prophet and attempt to forecast the future so far as he may, to a certain possible development which may revolutionize present conditions. Not the least of these problems, with the world in its present chaotic condition, is the supplying of raw materials. An important consideration always, it is tenfold more difficult today in view of embargoes and governmental requirements which develop with startling frequency.

The careful tests, both chemical and physical, which must continually be made to insure uniform quality of product are today employing a constantly increasing force of experts. For not only must every part that enters a modern machine be along the lines of the building of the "Wonderful One-Horse Shay" of poetical renown, but also a deviation from standard may completely upset the progress of fabrication in the well-ordered production of a modern factory. The duplication of parts by dies, jigs, and special machines has developed the use of gages and templates to a fine art, and the variation of 0.001 in. has become a matter of more serious import than the blacksmith's "hair" (popularly supposed to be 1/8 in.) of a decade ago.

Efficiency in factory reproduction is by no means confined to the simple ability to make thousands of duplicate parts within very close limits as to size and quality. The value of timeliness is of equal importance, so much so, that to produce a thousand automobiles a day and find that the supply of a single certain small bolt had failed would be a supreme disaster. Factory reproduction depends absolutely for its success upon the ability to have an adequate supply of the right things at the right time, and the financial success of the institution is largely influenced by having as small an amount of capital tied up in supplies as manufacturing conditions warrant.

Between this Scylla and Charybdis has stepped the modern production manager who simulates the tight rope walker with 100 per cent production efficiency at one end of his balancing rod and minimum capital investment at the other.

The efficient planning department feels the throbbing pulses of factory production and the error of a single beat rouses it to instant action.

It is from this conning tower of the modern factory that go the impulses, properly graduated, that produce each day their quota of finished products from the assembly of the thousand parts. The progress and quantity of every part in process of manufacture and the certainty of its appearance in the department in which it is needed not a day too soon and by all means not a day too late, is of supreme importance. This is made possible by an elaborate system of planning boards which are constantly being studied and adjusted from the never-ending stream of progress, reports passing to this department from all departments of the factory.

Accuracy is of much more importance than mere amount of production. Not only may inaccuracy make a worker's own time a total loss but also the material involved and the labor done upon it by others, to say nothing of the disastrous effects it may have on the general production. Following accuracy, speed is a highly important feature directly related to the ever-present specter of overhead expense to the factory and earnings to the worker. Waste motion is a fruitful source of loss to all concerned, and time and motion study men have been brought into existence to assist in determining the most efficient method of performance. Expensive machines, efficient in themselves, but half solve the problem of reproduction if the worker has not been taught to develop them to their maximum capacity.

THE DISCUSSION

C. J. P. Lucas:—Previous to this war I went through factories in England, France and Switzerland. In these factories many women were employed. Since the war I have been especially interested in the factories in France where, in one factory alone, 17,000 women are employed, whereas previous to the war about 2000 were employed. I would like to ask Mr. Carlisle, owing to the present labor shortage in the United States, whether or not any investigations have been made on this side regarding the ability of women for work in metal-working plants.

F. A. Carlisle:—So far as I know no official investigations of any degree of completeness have been made, but a number of industries have, because of labor shortage, made private investigations for their own information. One big outcome of these investigations is the discovery that we have been dependent upon a certain

*General Manager, Friedlander-Brady Knitting Mills.

amount of brute strength. It has been found necessary to alter machines for female labor, and what we have considered standard has had to be changed for greater efficiency and for more effectively meeting the calls of labor. We have all kinds of women as we have all kinds of men. Women are more nervous and high-strung, but for speed in pure routine operations the women far exceed men in their ability. But for those operations which require strength we find the women have not done so well. In our own factory we have substituted female labor for male in a number of cases. I am ashamed to say that in one case where we were obliged to place women we found out that the dies they had to move were too heavy for a woman to lift. We had to spend several hundred dollars to alter the machines. This led to a little figuring, and we discovered that we had been placing 780 tons a year excess weight upon a man, had been paying him for it, and that it did not do a bit of good. Changing conditions tend for more efficient operations.

A MEMBER:—What methods are found best in dealing with the laboring people, especially the labor leaders, in convincing them that this efficiency movement is to the interest of the laboring man and to lighten his task?

F. A. CARLISLE:—Sacred history has it that at the building of the Tower of Babel men of every tongue were confused and were unable to understand each other. Nevertheless, there is the question of compensation and the pay envelope—something they all understand. No help are so ignorant that they cannot read an increase in the pay envelope. I have employees who are unable to read or write English; it is very difficult to convey an idea to them. If the work is wrong it is impossible to show them where the trouble is. If you ask them to do a thing differently one can hardly get them to do it. But if their pay envelope is one cent short, they always know it. Therefore, gentlemen, so long as a man sees it is to his advantage, financially, to earn more money with approximately the same effort, it requires an argument for organized labor to make an impression on him.

RESEARCH COMMITTEE FORMED

THE following statement is authorized by the Council of National Defense. By joint action the Secretaries of War and Navy, with approval of the Council of National Defense, have authorized the organization, through the National Research Council, of a Research Information Committee in Washington, with branch committees in Paris and London, which are intended to work in close cooperation with the officers of the Military and Naval Intelligence, and whose function shall be the securing, classifying and disseminating of scientific, technical and industrial research information, especially relating to war problems, and the interchange of such information between the Allies in Europe and the United States.

The Washington committee consists of: (a) A civilian member, representing the National Research Council; Dr. S. W. Stratton, chairman. (b) The chief, Military Intelligence Section. (c) The Director of Naval Intelligence.

The initial organization of the committee in London is: (a) The scientific attache representing the Research Information Committee; Dr. H. A. Bumstead, attache. (b) The military attache, or an officer deputed to act for him. (c) The naval attache, or an officer deputed to act for him.

The initial organization of the committee in Paris is: (a) The scientific attache representing the Research Information Committee, Dr. W. F. Durand, attache. (b) The military attache, or an officer deputed to act for him. (c) The naval attache, or an officer deputed to act for him.

The chief functions of the foreign committees thus organized are intended to be as follows:

(a) The development of contact with all important research laboratories or agencies, governmental or private; the compilation of problems and subjects under investigation; and the collection and compilation of the results attained.

(b) The classification, organization and preparation of such information for transmission to the Research Information Committee in Washington.

(c) The maintenance of continuous contact with the work of the offices of military and naval attaches in order that all duplication of work or crossing of effort may be avoided, with the consequent waste of time and energy and the confusion resulting from crossed or duplicated effort.

(d) To serve as an immediate auxiliary to the offices of the military and naval attaches in the collection, analysis and compilation of scientific, technical and industrial research information.

(e) To serve as an agency at the immediate service of the commander-in-chief of the military or naval forces in Europe for the collection and analysis of scientific and technical research information, and as an auxiliary to such direct military and naval agencies as may be in use for the purpose.

(f) To serve as centers of distribution to the American Expeditionary Forces in France and to the American naval forces in European waters of scientific and technical research information, originating in the United States and transmitted through the Research Information Committee in Washington.

(g) To serve as centers of distribution to our allies in Europe of scientific, technical and industrial research information originating in the United States and transmitted through the Research Information Committee in Washington.

(h) The maintenance of the necessary contact between the offices in Paris and London in order that provision may be made for the direct and prompt interchange of important scientific and technical information.

(i) To aid research workers or collectors of scientific, technical and industrial information from the United States, when properly accredited from the Research Information Committee in Washington, in best achieving their several and particular purposes.

The headquarters of the Research Information Committee in Washington is in the offices of the National Research Council, 1023 Sixteenth Street; the branch committees are located at the American Embassies in London and Paris.

Fuels for Tractor Engines

By Prof. J. L. Mowry* (*Member of the Society*) Minneapolis Section Paper

It is evident that much time and money have been spent in the enlistment of technical skill to the end that the production of internal combustion engine fuel may keep pace with the rapidly increasing demand. Therefore let us focus our attention upon engine production and operation—with food for thought drawn from limited laboratory and more extensive field observations.

Oil Refiners

Beyond doubt the oil refiners would have us use a fuel which they can produce in largest possible volume, of the highest possible specific gravity, and lowest volatility. We are using, with a large measure of satisfaction, fuels which have an end-point of 450 deg. fahr. How much farther than this can we go? How much farther will we be asked or *forced* to go?

Accessory Manufacturers

Manufacturers of carburetion devices will warmly welcome the arrival of a fuel of constant characteristics. Their problem has been highly complex—the delivery of a variable fuel under varying load, speed and weather conditions. Much has been accomplished, but an examination of the field of tractors reveals the fact that in the end the adaptations have been made by the engine designers and builders and to them is largely due the present measure of success in burning heavy fuels.

It has been argued that engine and carbureter designers have been working along lines not parallel, but so slowly converging that their meeting point is discouragingly far distant. It cannot be denied that most tractor engine builders are too content with an adapted automobile carbureter. The more efficient utilization of present fuels and the possible use of still heavier oils is more contingent upon engine than upon accessory design.

The spark-plug manufacturers are making every effort to combat the evils of high temperatures and unequal expansion of materials. Present international relations may be, in part, blamed for the state of the industry but they should, on the other hand, be a powerful incentive to American producers to invent or discover the necessary dielectric and electrode materials. Spark-plug failures are by far too consistent in our present kerosene engines. Plugs have been in constant use for three years without being cleaned but probably in such cases some credit must be given engine design, lubrication and carbureter adjustment. A tractor operator who must replace one to four plugs per day is exceedingly unfortunate.

Without intending to open up at this time the subject of battery vs. magneto ignition, it is my belief that we shall depend upon the latter in tractor work. I have nothing to exact from magneto manufacturers from the standpoint of tractor fuels. We do need, however, a better product from an insulation and dielectric standpoint.

Engine Builders

The engine designers and builders are looking for a fuel which will permit the use of standard materials, the combustion of which is not destructive of engine parts, which is not destructive of the lubricant, and one which will burn clean.

Our field men and designers are all too familiar with valve failures and partial combustion. The latter, it must be admitted, is in some measure due to quality of lubricants.

It is human nature and habit, born of respect for past achievements and successes, to cling to standard practices. I want to venture the opinion that the present poppet-valve engine is at its height. In so saying, I confess that the substitute is not forthcoming. Far more seemingly insurmountable tasks have been mastered in the past nine months.

Operators

The users and operators are the men who finally locate our errors and direct our successes. This class of men demands a fuel which is easily obtainable in all markets, is of constant quality, and is non-destructive of parts and of the lubricant. They do not care what this fuel may be, provided they can get from it reliable power at low cost and small upkeep.

Of many users of tractors only 8 per cent objected to the cost. Of this number some were purchasers of the lowest-priced tractor on the market, and one had been enjoying free service covering both labor and parts. Price objections may therefore be considered lightly.

Field Observations

The attitude of the user can best be shown by an analysis of returns from 400 users of tractors in the State of Minnesota. To be fair to the manufacturers, all machines older than three years were eliminated as being out of date.

It is to be noted that no distillates were used, likewise no motor spirit. Gasoline and kerosene were used exclusively. Of the total, less than 12 per cent used gasoline, except for starting. It is evident, therefore, that the farmer is a user of low-grade fuel.

The average time lost in the field due to engine troubles was 30 minutes, with a range from 15 minutes to 3 hours. This is surely not an unreasonable time for minor field troubles; from this much satisfaction may be derived by designers and builders. The service men can point to such a showing as indicative of their success in making new owners passable operators within a very few days.

It is worthy of note that a man might not advise his neighbors to follow in his footsteps, although satisfied with his own investment. His ego crops out; he considers himself a better mechanic than his neighbors. While only 7 to 8 per cent doubt or deny the success of their purchases, over 40 per cent would not advise Mr. Average Neighbor to make the same investment. In the light of these reports it is rather difficult to make a case against present tractor fuels.

It is to be noted also that the success or failure of a tractor in the hands of a farmer is contingent upon the size of his repair bills. The average age of these three-year tractors was eighteen months, and the average yearly repair bill was \$28.05. This should be encouraging to the designers and sales organizations.

*Associate Professor of Agricultural Engineering, University of Minnesota.

There is food for thought for those who would advocate electric starters for tractors, in the average number of days' use per year—50.8. The care of the storage batteries during the idle periods is of utmost importance.

Laboratory Tests

We have been able to pursue investigational work to a very limited extent. The necessity for diluting trained help, and the demand for advice and instruction on automotive machines, due to over-seas conditions, has curtailed work which should have been in progress or completed.

With a four-cylinder removable-head L-type engine the following results were obtained, with three kerosene devices:

Fuel, kerosene.
Time, 1 hour.
Water, 190 deg. to boiling.

Series No. 1—Clapper Manifold.
Engine speed, 760 r.p.m.—full load.
Result, oil in crankcase increased 0.1 lb.

Series No. 2—Holly Vaporizer.
Engine speed, 820 r.p.m. (to get same horsepower).
Result, oil in crankcase increased 0.7 lb.

Series No. 3—Duplex Manifold.
Engine speed, 820 r.p.m. (same horsepower).
Result, oil in crankcase increased 0.3 lb.
Engine stopped after 35 minutes, due to preignition.

The chief point of interest to be drawn from these tests is that the "hot-spot" manifold gives more promise than others. This finding is not at variance with what others have disclosed. It is also quite in accord with the present trend of kerosene-burning devices. It is worthy of further study and development.

Possible Fuels

Without again going over well-trodden paths by which tractor fuels may be found or made available in large quantities the present possibilities are:

1. Cracked heavy oils—too high cost.
2. Casing-head gas—limited in quantity.
3. Alcohol—too high cost.
4. Alcohol and gasoline—which may be mixed under such conditions as to remain homogeneous for some time—too high cost.
5. Synthetic gasoline—still too expensive.
6. Set or fixed gas. This would seem to possess the most promise.

To offset high cost of fuel, engine design and economy may come to the rescue.

Author's Conclusion

While waiting for the further development of substitute fuels, the present article must be utilized. This requires:

1. Better spark-plugs.
2. Manifold development, with the hot-spot principle demanding major attention.
3. Carbureter development with means provided for quickly changing to a lighter fuel to take care of overload and throttling conditions.
4. Engine design with special stress upon cooling of and elimination of moving parts.

THE DISCUSSION

W. G. Clark (M. S. A. E.):—During the past three months I have been with a school conducted by a large tractor company. We have covered the tractor belt through the middle and southern states, from Texas to Montana; the reference made to the 8 per cent of farmers who are not fully satisfied, but who are a part of the 40 per cent who would not advise neighbors to buy the same tractor, states the case well. I believe it means the farmer, having bought a tractor which he is not quite sure about, does not want to publish the fact that he has been "stung," but he is kind enough not to allow his neighbors to be "stung." However, the situation in Minnesota is better than in other parts of the country. I have come in personal contact with some fifteen to eighteen hundred tractor owners and operators in the past three months, and my point of view has been changed. The situation is really much worse than we imagine. The tractor and accessory manufacturers are to blame.

The solution of the present fuel problem evidently is in the use of low-grade fuel, but, notwithstanding that and the attempt of manufacturers to force this solution upon the public, we find a growing prejudice against low-grade fuel. I say that advisedly, having the past three months' experience in mind.

Our methods of trying out our fuels have involved too much laboratory work, I fear, because certain methods of handling fuels in field operations do not correspond with the methods obtainable with a new and clean engine under laboratory conditions. I do not agree with Professor Mowry that the solution of the problem lies in the hot-spot manifold principle. We receive hundreds of letters every day from engine owners and operators who have so-called kerosene tractors asking if we can guarantee our tractor to burn kerosene. They say, "We have a kerosene tractor that does not burn kerosene."

Two men who had a tractor that was sold to them as a kerosene tractor came to me last week. They had used it a year and a half and had used nothing but gasoline, although it was outfitted with a kerosene equipment. They had written to the manufacturers for information regarding the handling of kerosene, and, much to my surprise, the reply was that they should stick to gasoline. After advertising and selling their tractors to burn kerosene they advised the owners to use gasoline! What is the explanation? Evidently after selling it they found out it would not do as expected. If we will do what Mr. Beecroft suggested—sacrifice our prejudices—and cooperate with the accessory men and the engine men, we can improve these things so that they will work.

Hot-Spot Manifold

A great many complaints have followed the use of the system of burning kerosene with the hot-spot manifold. That is why I disagree with Prof. Mowry. Before this past experience I had the opinion that he holds now, that there were greater possibilities in that type of handling fuels, but my faith in it has been sadly shaken because nine-tenths of our complaints have come from owners employing that system of burning kerosene. As Prof. Mowry has said, we have been too satisfied with past performances of standard products and too loath to make changes in engine designs which are now proved absolutely necessary to handle low-grade fuels.

Kerosene, every one admits, requires some distinct external means to assist its vaporization, and the only means at hand at present is the use of heat. Since heat must be used it is obvious that the conditions of cooling and temperature control available in the ordinary gasoline engine will not do for the kerosene engine. But those are things which engineers themselves are loath to supply, resulting in the dissatisfaction now prevalent among tractor owners.

I want to state briefly my reasons for losing faith in the hot-spot manifold. I am not talking from a selfish standpoint because we are using carbureters that handle fuels with the hot-spot manifold as well as the others.

The present forms of the hot-spot or duplex manifold are very imperfect for the obvious reason that using a double or duplex manifold means that the entire charge of fuel and air is heated, and in the forms of existing manifolds there is not one I know of that heats the charge uniformly. Consequently in a multiple-cylinder engine one cylinder does not get a charge exactly like the others. The result is preignition, which is hard to control.

Extra Weight Objectionable

Another reason is that it is impossible to maintain the same power with kerosene as with gasoline. No farmer that I know of is willing to carry around an engine that has 25 per cent extra weight simply for the satisfaction of burning kerosene. He wants to obtain the most work in the shortest time at the least cost. If he has a tractor that pulls three plows he puts on another to see if it will pull that. If one has a 40-hp. engine and gets only 30 hp. after putting on a hot-spot manifold he will have to carry around the equivalent of 10 hp. that does not render service, and the farmer will not tolerate that. Some tractors must have extra weight to hold them on the ground. The average tractor owner is becoming educated and knows what power to expect from an engine of a given size. That is the main reason why that system of burning kerosene is not practical. We want all the drawbar horsepower possible with a minimum weight.

Another objection to the hot-spot manifold results from the unequal distribution of the heat; the results are cracking inside, dilution of lubricant in the crankcase and deposits in the manifold. We know of many thousands of tractors which are being run on dry gas, and they do not have crankcase dilution, but they are not using the hot-spot manifold. Getting so much addition to the oil through dilution is an indication of incomplete combustion. The obvious remedy is to apply something that will give complete combustion. According to the figures given by Professor Mowry duplex manifolds do not result in complete combustion, and I think that is an argument against them. We know of several systems of handling kerosene which give complete combustion. We hear much about kerosene and gasoline engine lubricating oils. With perfect combustion I do not think any change in oil need be made. We have to use heat to vaporize kerosene and when we use heat we have to use more fuel. The least amount of heat should be used in the most economical way possible to get perfect combustion. The solution of the low-grade fuel problem appears to lie in the proper application of heat without the sacrifice of flexibility and economy.

The distinction has not been drawn fine enough between merely running an engine on kerosene and really burning kerosene. Too many manufacturers have been content to say "it will run on kerosene," without being able to guarantee that an engine will burn *all* the kerosene. A gasoline engine can be made to run on kerosene if one does not care how much it burns. It is the sale of such tractors that has created prejudice against kerosene as fuel. Kerosene is a good fuel if handled properly. As I have said, the remedy lies in the accessory and engine men getting together.

Prof. Mowry has been a little hard on the spark-plug makers. It is true that a few months ago, owing to the disturbances caused by the war, several lots of bad spark-plugs got out on the market. There are, however, spark-plugs on the market today absolutely satisfactory for handling kerosene. I have seen plugs in service two years and a half which have never been cleaned and have never required cleaning. I think a large part of spark-plug trouble can be located in the crankcase owing to improper arrangement or care of lubrication. Most oils have some good qualities, but the best oil, if not kept clean, is no better than poor oil. We have found, in thousands of cases of engines which are even fairly well lubricated, that if the oil is kept clean spark-plug troubles will be eliminated, provided a good spark-plug is used in the first place. Putting too much stress on the spark-plug question, therefore, is not quite fair.

CHAIRMAN GREER:—Most of the hot-spot manifolds in use today have no heat control. The heat to the manifold is greatest at full load and much lighter at light load. That is the reverse of what is desired.

A. C. BENNETT (M. S. A. E.):—One thing, perhaps, Professor Mowry and Mr. Clark have not brought out, that there is more or less condensation of the kerosene in the manifold with uneven loads, such as are usual under actual working conditions. If a large amount of heat is not used with the hot-spot manifold when operating at light loads, condensation is likely to result. Possibly some improvements can be made in the hot-spot manifold, or hot-jacket, as it is commonly called, which would give better results.

Lubrication

MR. CRANDALL:—My experience during the past seven years has been mostly in the field, in Montana, Minnesota and Wisconsin, partly in high altitudes and on the prairies. I take exception to Mr. Clark on one or two details. One point is lubrication. A heavy-bodied oil must be used when burning kerosene. If the tractor has complete combustion, that is, the kerosene is vaporized so that there is no smoke from the exhaust, it is still necessary to use heavy-bodied oil. I have had experience with that in the mountains on the gumbo tableland where the plowing is very heavy, and I have tried to burn the ordinary gasoline-engine oil and have found that it cannot be done successfully with kerosene. One reason is that the temperature of the kerosene engine must be higher than that of the gasoline engine, and when the engine is running at full load the cylinders will run dry; I have opened the crankcase on a gasoline engine and put my hand on the cylinder and found it to be almost dry. Changing to kerosene tractor oil gives better lubrication; that is a recognized fact, and oils for that special purpose are put out.

Another thing, gasoline, like kerosene, goes by the piston. I think the best way to completely vaporize the kerosene in order to operate the kerosene engine successfully is to heat the manifold.

Two-Cylinder Engines

My experience has been mostly with two-cylinder engines, the intake and exhaust manifolds being cast together. By night time the exhaust manifold would become very hot, the intake manifold inside of that would be fairly hot and the vaporization of gas would be complete. In the field there is scarcely any smoke after a twelve-hour stretch, but at any time the engine could be loaded up with kerosene so as to emit volumes of smoke. It will work as successfully on kerosene as on gasoline, but it is difficult with a four-cylinder engine to get

the intake and exhaust manifold cast so as to heat evenly. I think the thing we should work for now in the four-cylinder engine is to heat the kerosene evenly up through the manifold. To do that it is necessary to have a short manifold.

The two-cylinder opposed engine cannot, of course, be operated successfully that way. It is almost an impossibility to avoid condensation in a long intake pipe. I think the idea we have got to work to is to bring the kerosene on the four-cylinder tractor immediately to the point where it is completely vaporized when it goes into the cylinders and not allow condensation in the angles of the intake pipe.

I have done expert work on tractors for about seven years and am positive that the tractor can be brought up to the point where it will burn kerosene as successfully as gasoline.

G. C. ANDREWS (M. S. A. E.):—Loss of power with kerosene might be due to preheating; in changing from liquid to vapor form some of the explosive force might be lost.

MR. CRANDALL:—I believe Mr. Andrews' point is that in vaporizing gas to a great extent before it enters the cylinder we lose considerable power. I think just the opposite is the result; if the gas is completely vaporized before entering the cylinder there will be a concentrated and a clean explosion, whereas the fuel entering in too raw a state has the same effect as too rich a mixture in an automobile. If an engine were started with too rich a mixture or very raw gas the explosion would occur all right, but it would not have the force, the combustion would not be instantaneous. I think that kerosene taken into the cylinder in too raw a state is partly the cause of loss of power instead of the opposite being the case.

MR. COUSE:—Twenty-five per cent more power with 10 per cent less fuel consumption has actually been secured by burning kerosene.

C. S. WHITNEY (A. S. A. E.):—Prof. Mowry made the statement, I believe, that fifty days of the year were all that the tractor would be used. In replying to a question put to me as to whether a storage battery would freeze, I made the statement that, of course, if the owner of the tractor put it away for the winter season he should take the storage battery out and put it some place where it could be taken care of. When I made that statement at the last meeting, Professor Chase, of the University of Nebraska, protested vigorously, contending that the tractor works the year around, cutting feed and doing other work. "You have got to produce something that works 12 months in the year," he said.

PROFESSOR MOWRY:—The figures I cited are Minnesota figures; they are not general over this part of the country. The range was from 21 days to about 130; two or three used them as much as 130 days, running well into the winter.

CHAIRMAN GREER:—In that connection, I know some tractors are not used during many days in the winter but must be kept in the sheds all the time. They may be used for only two or three hours, perhaps once a week, during the winter months, but they are needed.

Effects of Low Temperatures on Starting

DISCUSSION AT CLEVELAND SECTION MEETING

THE original paper, of which the following is the discussion, was delivered before the Cleveland Section, by O. W. A. Oetting, and was published on pages 151 to 156 inclusive of the February, 1918, issue of THE JOURNAL.

A MEMBER:—In the case of lubricant actually frozen or solidified, was the power required to roll the engine after it was broken loose found to be less or greater than when the oil was not frozen?

O. W. A. OETTING (M. S. A. E.):—I have no exact data on that point. More power would be required after it was frozen, for it would probably have to run for a little while to bring up the temperature.

A MEMBER:—Would the average starter break it loose when frozen that way?

MR. OETTING:—We made tests of different grades of lubricating oils in test tubes, our one object being to find out if any engines were using a grade of oil that would solidify, and, if so, we did not use it. I remember removing the thermometer from one test tube of oil that had stood over night, a hole remaining in the oil.

A MEMBER:—Was a good rule formulated for picking out a good oil?

MR. OETTING:—No, it was not. There should be definite specifications written by automobile engineers for testing oils and for recommending to car users oils of suitable qualities for successful service. That, however, is a little out of our line in making these tests.

CHAIRMAN STRICKLAND:—One takes chances putting light oil into a high-powered engine to take care of freezing temperatures, especially if one is going to travel rapidly after starting the engine. We have heard a good deal the last two winters about these conditions. We have been getting water in the crankcase and thinning the oil. In some cases I believe that water circulates with the oil, and, when stopping, more or less moisture is left in the bearings, and that freezes, and is partly responsible for "sewing up" the engines.

JOHN MCGEORGE (M. S. A. E.):—The whole bearing of the paper seems to be that the low temperature freezes up the engine, and that the whole burden is the fault of the oil in the engine. Is it not a fact that some fault lies with the battery itself? Is there not some effect of the low temperature on the action of the battery?

MR. OETTING:—Yes. The fact was mentioned that at 10 deg. fahr. the battery capacity is 50 per cent of nor-

mal at normal temperature. It is an inherent quality of the battery that cannot be changed in any way. We must design with that in mind.

A MEMBER:—Have you tested an engine with "Oildag" in the oil?

MR. OETTING:—No.

A MEMBER:—When using it the engine has approximately the same friction in cold as in warm weather, after it has been broken loose. That is one of its peculiarities. I had occasion to try that recently on an engine that had been standing in the cold, unused, for about one month; after I broke it loose it cranked as easily as in summer time, and also started properly. To break it loose I just pulled on the starting crank. It was not very hard. That engine has had "Oildag" in it from the time it was tested, about six years ago; the valves have never been ground, and the compression is as good as ever. Except for the last two or three months it has run every day for five years. "Oildag" is graphite, and is so fine that it will go through a porcelain filter without clogging. If the cylinder is cracked, after running an engine with it about five or ten thousand miles a little line will be noticed where the "Oildag" has gone into the iron. I would also like to say that it is the invention of an American chemist, and less is sold in this country than anywhere else.

A MEMBER:—I might add that I had trouble with my car; when I started up, the pistons stuck; by using "Oildag" I avoided this trouble.

A MEMBER:—Does the temperature of the electrolyte make any difference, and does it have the same effect at all densities?

MR. OETTING:—At about 1.300 density of the acid electrolyte the freezing point is about —90 deg., and as the density becomes less the freezing point is raised. It is best to keep the battery charged so it will not freeze—that is, about 1.300 density.

A MEMBER:—Suppose the density is down to one-half of normal. There will be a certain discharge from the battery if the motor is started at a temperature of, say, 50 deg.; now, would there be the same percentage of drop at 10 deg.?

MR. OETTING:—I think the percentage would be the same, but it is dangerous to let the battery go down in cold weather.

Larger Batteries Advisable

A MEMBER:—Should car manufacturers use larger batteries?

MR. OETTING:—The majority of them ought to have larger batteries. As Fig. 1 of my paper showed, no relation between engine size and battery size seems to have been adopted. There should be a definite relation, and I would say 75 per cent ought to have larger batteries.

A MEMBER:—In view of the fact that manufacturers will not pay more money, would it not be feasible to use thinner plates?

MR. OETTING:—Thinner plates cut down life. I think the majority of manufacturers put in batteries that usually last 18 to 24 months.

CHAIRMAN STRICKLAND:—It seems to me that the curves used in the paper were based on average conditions. The first chart shows the sizes of batteries on all the cars, and of course it could be said that those under the average line should have larger batteries and those over the line should have smaller batteries. There are other causes of batteries running down than say the use of thin plates or the installation of too small a battery. Could you tell us, by percentages, some of the causes of batteries running down?

T. R. COOK (M. S. A. E.):—I do not know that one can tell; the battery simply runs down after giving out so much current. The result of deterioration of the plate is overheating in summer time. With a large battery installed one can charge sufficiently to take care of conditions in winter time, and yet not overheat the battery in the summer time. Records from our service stations show that the average battery life is about 24 months. That applies to batteries used on different makes of cars. There is one particular car that has an oversize battery, and all the batteries installed in that car have a life of 30 months, while cars using smaller batteries come in in 12 or 16 months. I think it is safe to say that the greatest trouble is overheating in the summer time on the smaller batteries. With a small battery, the charging necessary to take care of the cranking and lighting in winter time is of such amount that in summer time the battery temperature would increase to 140 deg. or 160 deg., with the result of rapid shedding of the plates.

A MEMBER:—I do not believe the size of the battery makes much difference; for instance, starting out at 10 deg., and making several calls, and taking over 15 seconds every time to start the engine, how long would 150 amperes last, inasmuch as the engine would not get warm enough to run over five miles an hour? What difference would size make if the engine would not start after one hour's use?

Motor Efficiency

CHAIRMAN STRICKLAND:—That point is well taken. I think the causes of batteries running down are various, and it will happen with the best and largest batteries. One conclusion seems remarkable to me, because it differs from the basis we originally started out with. It was in reference to the design of the motor for efficiency; a question came up as to whether to have it efficient at high-cranking speed or at low-cranking speed. The basis on which we formerly worked was to have it efficient at the standard cranking speed, which at that time was around 125 r.p.m. under ordinary conditions; our assumption was based on the belief that batteries were run down really on account of other troubles—ignition or carburetion. Our claim was that the more efficient we made the motor at that speed the longer one could keep on spinning it, and finally get started; or in other words, there would be more life in the battery. Now, these cold spells, 10 deg. and colder, where tremendous current is required for low-speed cranking, do not occur very often, and I do not consider it policy to proportion the motor to have its best efficiency at those low speeds. The conclusion in the paper differs from that view, and I would like to hear any other questions for that reason. I think some of the trouble lies in the generator upkeep not being proper; for example, brushes allowed to wear down.

MR. COOK:—In the winter time more lighting is required than in summer, and it is therefore desirable to take out as little current as possible. Consequently, better motor efficiency at low speeds is of advantage.

CHAIRMAN STRICKLAND:—I did not mean to advocate maximum motor efficiency for summer time; neither do I think that the author meant at 10 deg. He referred to low speeds; what speeds does he mean?

MR. OETTING:—Until recently, we were ignorant of the fact that cranking speeds of 10 to 20 r.p.m. were obtained at 10 deg. fahr. The starter should be designed to have

higher efficiency where it is most needed. If a car can be started at 10 deg. it can be started easily at 70 to 80 deg. The point I made in the paper is that the battery size is determined by the power necessary to crank the engine at 10 deg., and what will take care of it at 10 deg. will take care of it at any temperature. As shown on the chart, I had 10 deg. as an average low temperature. Many places get as cold as —30 or —40 deg., but those are extreme conditions that it would not be right to ask manufacturers to meet.

Evaporation of Water

A. J. SCAIFE (M. S. A. E.):—With a small battery the water evaporates very rapidly in summer. I imagine that it is very hard on the plates, and know of a 12-volt battery that during summer would go for a month before the water would get below the top of the plates. It was a battery of ample capacity, and as it was large enough to take care of the output of the generator it never became very warm, so that the water was not evaporated.

CHAIRMAN STRICKLAND:—I believe the battery people advise filling frequently in summer time.

MR. OETTING:—Fill the battery once a week for constant running in summer.

A MEMBER:—What would be the effect of putting oil over the surface of the battery?

MR. COOK:—That was done years ago, but it did not have the desired effect. When trying to put in more current than the battery can take the battery starts to give off gas, and the electrolyte level drops.

CHAIRMAN STRICKLAND:—How long was the engine left in the cold room before making these tests?

MR. OETTING:—To get an engine down to zero, or 10 deg., it had to be left in the box over night to insure a uniform temperature throughout. That is also the reason for putting anti-freeze in the cooling chamber to insure a uniform low temperature.

CHAIRMAN STRICKLAND:—I have found also that a car left in the cold two days is much worse than one left only one day. Probably it reaches a certain point where it will stand still, and I know leaving it from Saturday to Monday makes a decided difference.

A MEMBER:—The idea, apparently, is to install a very large storage battery to start the motor. I have a 12-volt, 120-amp.-hr. battery in a very small machine, and all this winter I have had no trouble whatever in turning over the engine. I have had considerable starting trouble, but have had none so far as spinning the engine is concerned. I have a double-ignition system. The car has been frozen, and although the storage battery would turn the engine over at a rate of speed that ordinarily would start the engine, I could not get the proper carburetion or ignition to further aid the starting; but I believe that it was due to the size of the battery in that small car. I had an experience with some transmission grease which absolutely prevented the starting of the engine until the clutch was released. That may sound peculiar, but that particular grade of grease congealed, and prevented the starter from turning over the transmission—just the constantly meshed gears.

CHAIRMAN STRICKLAND:—I think it is in order to ask whether a transmission was locked onto the engines tested.

MR. OETTING:—In most of the cases, I believe, we did not have the transmission in. Some persons claim they can start better with the clutch in, and some with the clutch out. This does not affect starting as much as one would naturally suppose.

A MEMBER:—This question may not be in order, but why use grease in the transmission?

CHAIRMAN STRICKLAND:—In winter, oil is like grease.

A MEMBER:—We have heard that it would be a good plan to have larger batteries; also that a majority of manufacturers object to too much first cost of batteries. We have arranged for oversize automobile rims. Why would it not be a good plan to work out a battery carrier in the same way, so that the purchaser could buy an oversize battery, if desired, and stand the extra expense?

A MEMBER:—That is all right, but there is no room for it under the front seat.

CHAIRMAN STRICKLAND:—If we could persuade the public and the sales force to let us place batteries on running boards we could take care of that. That matter has been covered by reviews on the subject of batteries in the automobile magazines, and it certainly would be desirable to have the battery in a more accessible position than it is on a large percentage of cars, and also to have room for a larger battery if an owner wished to put it on.

MR. SCAIFE:—Is it not true that the Government is now specifying practically the largest six-volt battery that has ever been used?

Liberty Truck Batteries

MR. OETTING:—The battery used on the Liberty truck is of heavier construction. The capacity is 130 ampere-hours, and this battery, as tested by the Government, must stand one million vibrations in 30 hours. It is built to stand service, and does stand service.

CHAIRMAN STRICKLAND:—How many miles does such a test represent?

MR. OETTING:—I do not know any way of determining what one million bumps in 30 hours means in actual service. I feel sure that a battery that will stand that service is going to stand at least three or four years' service under actual running conditions.

A MEMBER:—What sort of vibration are they subjected to?

MR. OETTING:—The battery is mounted on a platform and dropped 5/16 in. 560 times per minute; that is one million bumps in 30 hours, and they have withstood a little over two million such vibrations.

A MEMBER:—The Government is specifying plates at least ¼ in. thick on the batteries used in naval work. They have tested all the thin plates up to ¼ in., and have decided that the life and dependability of a battery is dependent on the plate thickness, everything else being equal.

CHAIRMAN STRICKLAND:—Is there any difference in the life of a twelve and a six-volt battery?

MR. OETTING:—None whatever; the cells are all alike. The rate of current per plate is the same, and there is no difference in the gassing.

A MEMBER:—Why are batteries placed in the present position in cars, the lugs placed so as to come under the edge of the seat, where they cannot be reached with a wrench?

MR. OETTING:—The battery manufacturer does not design the cars, nor put the accessories on the car. We have had great difficulty inducing the automobile people to put the battery in some standard place. Cars come into our service stations that require an expert service man for one hour to change the battery.

CHAIRMAN STRICKLAND:—Are the batteries that are placed under the skirting, which have a special long shape, growing in popularity?

MR. OETTING:—No; I think the square-type battery is the one that will come eventually if space can be found for it. It makes the best battery application, and permits the best mounting of the battery in the box.

A MEMBER:—Is it not a fact that manufacturers generally ought to use larger batteries?

MR. OETTING:—That is one of the principal purposes I had in mind in picturing these results, and was one of my conclusions. No doubt 75 per cent of the cars ought to have larger batteries on them. It would be better for starting and better for the life of the battery. The sizes recommended in this paper are probably not the last word on battery sizes; the table in the paper listed *minimum* sizes.

A MEMBER:—Why is a square preferable to the long assembly?

MR. COOK:—I do not know of any particular reason, except that it happens to be the type of battery most generally used, though I think it is better mechanically for the ordinary size battery. The case stands up better. From a battery standpoint, I do not think there is any preference.

A MEMBER:—The long assembly has one advantage on most cars in that it is much easier for the owner to reach and easier for the service station; they need not remove the cushion from the seat, and there is no risk of damaging upholstery. It is true that many of them are not of sufficient height. I have been somewhat partial to the long battery.

Correct Location in Car

A MEMBER:—What is the correct location of a battery on the car?

MR. OETTING:—The place of least vibration is usually chosen, and I think the automobile engineers have placed the battery under the front floor boards, or front seat, with the idea of gaining longer life there. I believe the automobile engineers, in putting it under the seat of the car, have chosen a fairly good place.

MR. SCAIFE:—Batteries under the front floor boards are difficult to place in position and to protect from the heat of the engine in summer. I know of the sealing compound on the battery melting owing to the heat from the engine and exhaust pipe.

A MEMBER:—Is it not true that it is impossible to protect this type of battery so that in washing the car the water will not get into it? Furthermore, it is impossible to locate the cells of a square battery so as to safeguard against short-circuiting between the cells. A long battery will obviate short-circuiting. With end-to-end assembly the positive and negative poles are farther apart. In fact, some 12-volt assemblies totally discharge themselves in two weeks without any connection other than leakage. That is of some importance. I think we have made tests on the ordinary square assembly and found it will discharge itself in 40 to 60 days under fairly bad conditions.

Lead vs. Nickel-Alkaline Batteries

MR. MCGEORGE:—I was in hopes of hearing something more of the low-temperature characteristics of the batteries themselves. I have had experience with electric batteries, but my experience with gasoline cars has been slight. The discussion regarding starting has been on the mechanical side of the motors themselves. In my earlier days I used nickel-alkaline batteries and had some bad trouble. Lead battery men told me it was because the battery would not stand the cold weather. At that time this battery was supplied inclosed in a tight case to keep it warm, and I very carefully inclosed my batteries first in wood and then in steel to keep them warm. In talking to Mr. Edison he asked me about the construction of the battery box. He said: "All that I ask is that the draft shall be kept off." Mr. Edison produced a telegram from a place whose temperature was 40 deg. below zero and it read: "Had the pleasure of towing four lead batteries yesterday." Is it any worse for a nickel-alkaline battery to be frozen than for a lead one? Tonight I heard for the first time an intimation from a lead battery maker that his battery's efficiency falls off when the temperature goes down.

MR. OETTING:—It is entirely true that at 10 deg. the capacity is about 50 per cent. During some tests on lead and nickel-alkaline batteries at low temperatures the lead battery gave all that was expected at the 20-minute rate at 10 deg. while we could not hold the rate with the nickel-alkaline battery.

A MEMBER:—I think some of the difficulties have been in not making exact comparisons. It is true that a lead battery will drop to approximately 50 per cent of its capacity, but the lead battery has lower internal resistance than the nickel-alkaline battery. The latter battery at low temperatures will not maintain its voltage at higher rates. I had the opportunity lately of testing some nickel-alkaline cells at low temperature when they gave only about 10 per cent of their normal capacity at a five or six-hour rate, while the lead battery gave 30 or 40 per cent of its capacity. In northern countries they take very great care, in operating nickel-alkaline batteries, to keep all compartments well inclosed, covered with felt and in some cases even keeping carbon lamps burning. I know of no cases where an electric vehicle using a lead battery has had to inclose or pad the battery to prevent it from getting cold.

A MEMBER:—If a battery is discharged and gives out 50 per cent of its normal capacity, will the rest of it be available if the battery is warmed?

MR. OETTING:—Yes.

A MEMBER:—When the ignition wires lead from a battery that is too small under cold-weather conditions, upon attempting to start the motor the voltage of the battery will drop so low that sufficient ignition cannot be obtained. I have seen attempts made for ten minutes to get a car started whereas the battery would start the engine immediately if the crank were used, allowing the battery to furnish only the ignition. This shows that instead of trying to exhaust the battery one could start under those bad conditions by using the battery only for ignition.

A MEMBER:—Is not the failure of the ignition due to the fact that at the time the spark takes place the greatest draw on the battery is from the starting motor.

MR. OETTING:—When using the proper size of battery for starting, the voltage will not go down so as to make the ignition faulty.

A MEMBER:—It was mentioned that these starters could not be designed to be more efficient at the low speeds; now, what change could be made in the starter to make it more efficient at high speeds?

MR. OETTING:—It is a matter of proportion of iron and copper in the motor. The point I made was that a design for cold weather will work at normal temperatures, 70 and 80 degrees.

A MEMBER:—Could that not be attained at less expense by having greater reduction?

MR. OETTING:—Yes, that was one of my conclusions. I think in a double-reduction there will be a higher breakaway torque. It is not the spinning power but the high

break-away torque that starts the engine. During a test not long ago on one of the largest engines adapted for electric-starter service we used a double-reduction on flywheel drive; at normal temperature the motor turned over at 90 r.p.m. In cold weather at 15 deg. the engine turned over at 75 r.p.m. The double reduction was 17 to 1 and the engine four-cylinder with 5-in. bore and 7½-in. stroke. The armature of a starting motor on a starter of this kind must be designed to have a high acceleration so it will not backlash on the flywheel.

PROPOSED SCREW-THREAD LEGISLATION

THE complete standardization of screw threads necessary to meet the requirements of the War and Navy Departments is proposed in a bill introduced March 5 in the House of Representatives by Hon. John Q. Tilson, a member of Congress from Connecticut. A bill somewhat similar to this was introduced in January, 1917, by Congressman Tilson, but proposed the standardization only of tolerances, clearances and allowances. No action was taken on the bill by Congress last year so that it has been again introduced in slightly modified form.

The bill has been referred to the Committee on Coinage, Weights and Measures, which held hearings on March 5 and March 7, the former being attended by John G. Utz, John Younger and Assistant Secretary Herbert Chase on behalf of the Society. At the March 7 hearing a letter from Chairman Bachman of the Standards Committee of the Society was read into the record. This stated that the enlargement of the engineering activities of the Society to include, in addition to the automobile, the aeronautic, tractor, motorboat and stationary gas engine fields, had multiplied its opportunities for standardization of screw threads many fold. As a result the Society has been devoting a great deal of time and a large amount of its funds, toward accomplishing a thorough and complete standardization of screw threads. Chairman Bachman's letter further stated that General Manager Clarkson and E. H. Ehrman are now in England as representatives of the Society in order to attend an international congress on the subject of screw-thread standardization. He cited this to show how intensely interested the Society is in the subject. Had such standards been established by an authoritative commission prior to the entry of the United States in the present war, an untold saving in time and material would have resulted. Much confusion now existing would never have occurred, and instead of each department of the Government employing screw threads made under as many different systems, all would be working to one standard. A large duplication of effort would thus be eliminated, and the production of tools and gages necessary to manufacture and inspect properly parts containing screw threads would be considerably conserved. Mr. Bachman expressed hearty support of the measure and offered the services of the Society as a whole or any of its members who may be chosen to assist in accomplishing this greatly desired standardization.

The bill introduced by Congressman Tilson to provide for the appointment of a commission to standardize screw threads is given in full below:

Sec. 1. Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That a commission is hereby created, to be known as the Commission for the Standardization of Screw Threads, hereinafter referred to as the commission, which shall be composed of seven commissioners, one, who shall be a commissioned officer of the Army, to be appointed by the Secretary of War; one, who shall be a commissioned officer of the Navy, to be appointed by the Secretary of the Navy; five to be appointed by the Secretary of Commerce, one of whom shall be the Director of the Bureau of Standards, two from nominations made by the American Society of Mechanical Engineers, and two from nominations made by the Society of Automotive Engineers.

Sec. 2. That it shall be the duty of said commission to ascertain and establish standards for screw threads, which shall be submitted to the Secretary of War, the Secretary of the Navy and the Secretary of Commerce for their acceptance and approval. Such standards, when thus accepted and approved, shall be adopted and used in the several manufacturing plants under the control of the War and Navy Departments, and, so far as practicable, in all specifications for screw threads in proposals for manufactured articles, parts or materials to be used under the direction of these departments.

Sec. 3. That the Secretary of Commerce shall promulgate such standards for use by the public and cause the same to be published as a public document.

Sec. 4. That the commission shall serve without compensation, but nothing herein shall affect the compensation of the commissioners appointed from the Army and Navy or of the Director of the Bureau of Standards.

Sec. 5. That the commission may adopt rules and regulations in regard to its procedure and the conduct of its business.

Aerodynamic Laboratory of the Leland Stanford Junior University

By William F. Durand*

THE following is taken from Part I of Report No. 14 of the National Advisory Committee for Aeronautics, Washington. The complete report comprises three parts, as follows:

Part 1—The aerodynamic laboratory at Stanford University and the equipment installed with special reference to tests on air propellers.

Part 2—Tests on 48 model forms of air propellers, with analysis and discussion of results and presentation of the same in graphical form.

Part 3—A brief discussion of the law of similitude as affecting the relation between the results derived from model forms and those to be anticipated from full-sized forms.

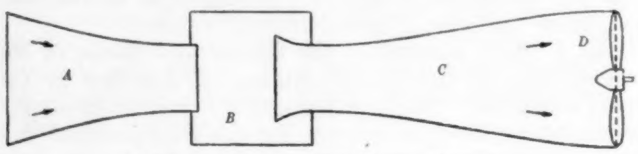


Fig. 1—Eiffel Type Wind Tunnel

The purposes of the experimental investigation on the performance of air propellers described in the full report were as follows:

(1) The development of a series of design factors and coefficients drawn from model forms distributed with some regularity over the field of air-propeller design and intended to furnish a basis of check with similar work done in other aerodynamic laboratories, and as a point of departure for the further study of special or individual types and forms.

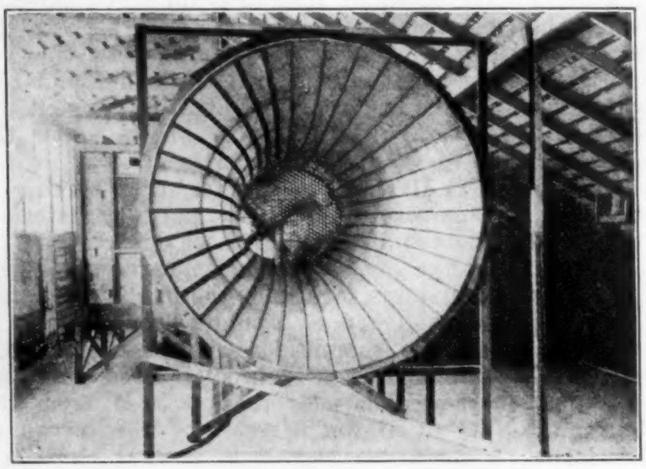


Fig. 2—Collector End of Wind Tunnel

(2) The establishment of a series of experimental values derived from models and intended for later use as a basis for comparison with similar results drawn from certain selected full-sized forms and tested in free flight.

The aerodynamic laboratory at Stanford University was installed during the fall and winter of 1916-17. The immediate purpose in view was the provision of an equipment for carrying on an extended investigation on air propellers, the first stage of which was planned for the year 1917.

The design of the laboratory described, the planning of the experimental work, design of the propellers, together with the preparation of the report, are the joint work of the present author and of Prof. E. P. Lesley of Stanford University. To the latter is due the entire supervision of the experimental work since April, 1917.

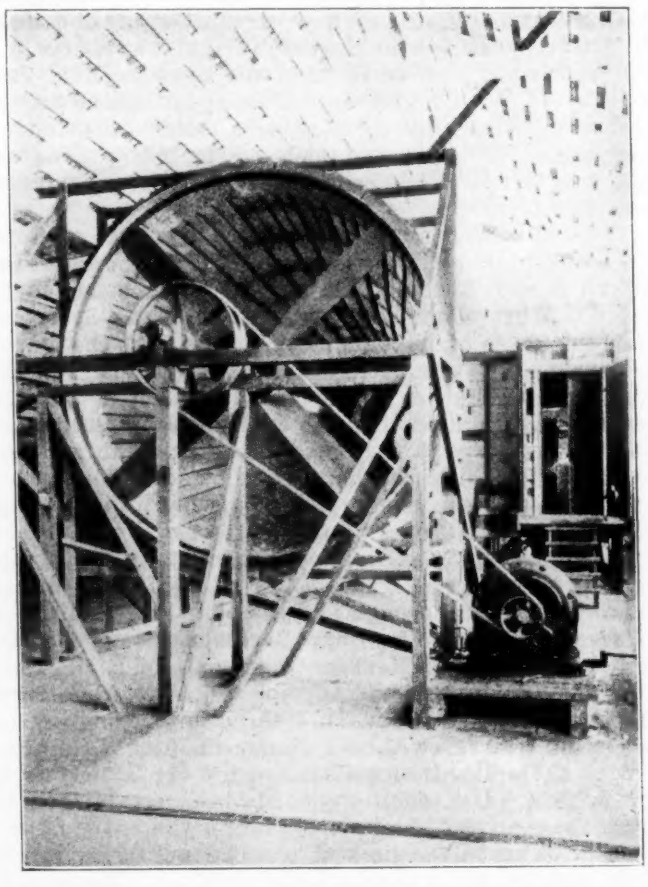


Fig. 3—Diffuser End of Wind Tunnel

The so-called Eiffel type of wind tunnel was adopted. This consists essentially of three elements—the collector *A*, the diffuser *C*, and the experiment chamber *B* (Fig. 1). At the end of the diffuser is located an exhaust fan *D*, which operates to draw the air from the diffuser and deliver it to the room in which the tunnel is located. This draft of air from the diffuser may be viewed as producing a reduced pressure in the experiment room, which is practically air-tight otherwise ex-

*Chairman, National Advisory Committee for Aeronautics.

cept for the entrance through the collector. In answer to this depression the air flows as through a nozzle, in through the collector, across the experiment room to the inner mouth of the diffuser, and thence on to the fan. The column of air thus flowing through the experiment room is then available for purposes of aerodynamic investigation.

The cross-section was taken circular and the diameter of the throat was fixed at 5.5 ft. as presumably suited to a propeller model 3 ft. in diameter, a size large enough to give not too wide a step in passing by a law of comparison from model results to those for full-sized forms.

The principal dimensions and general arrangement of the tunnel and experiment room are shown in Figs. 2, 3 and 4.

retardation as distributed along the distance axis *CD*. It was then thought desirable to judge the same distribution of velocity but on a time axis. To this end the transformation indicated in the diagram was effected. Considering *OEBF* as a curve of dx/dt, the reciprocal of this curve was laid off as indicated, giving a curve of dt/dx on an x axis. The integral curve of this was then run in as shown at O_1P, giving x as a function of t, or t as a function of x. O_1Q thus becomes an axis of time t and the curve *EBF* of velocity on distance is readily transformed into the curve $E_1B_1F_1$ of velocity on time by the construction indicated. Any ordinate as *AB* is continued to the curve O_1P, and from the point of intersection *R* an ordinate A_1R is drawn, and from A_1 a distance $A_1B_1 = AB$ is set up giving the velocity at the time O_1A_1

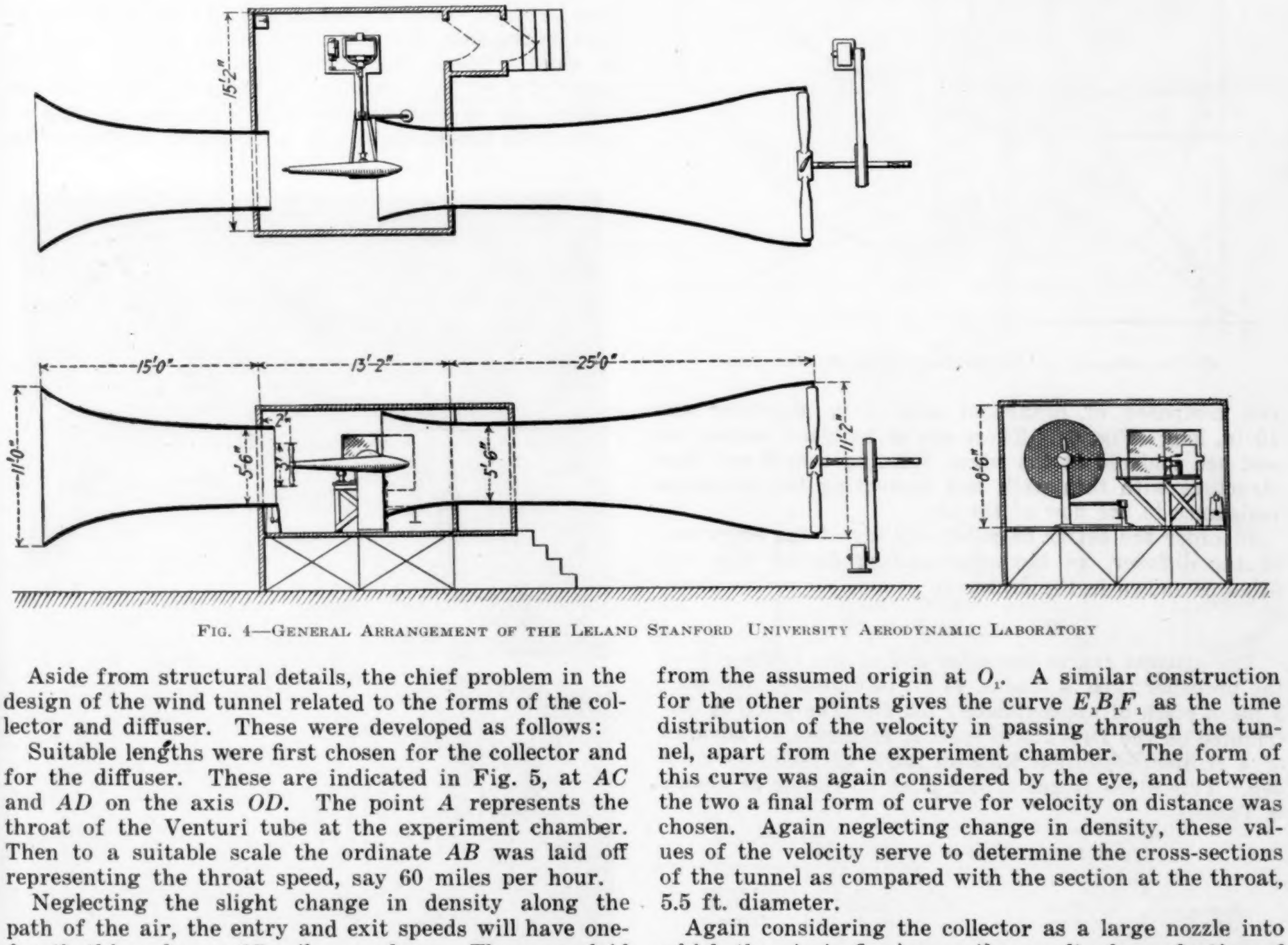


Fig. 4—General Arrangement of the Leland Stanford University Aerodynamic Laboratory

Aside from structural details, the chief problem in the design of the wind tunnel related to the forms of the collector and diffuser. These were developed as follows:

Suitable lengths were first chosen for the collector and for the diffuser. These are indicated in Fig. 5, at *AC* and *AD* on the axis *OD*. The point *A* represents the throat of the Venturi tube at the experiment chamber. Then to a suitable scale the ordinate *AB* was laid off representing the throat speed, say 60 miles per hour.

Neglecting the slight change in density along the path of the air, the entry and exit speeds will have one-fourth this value or 15 miles per hour. These are laid up as ordinates at *C* and *D*. A smooth curve was then drawn in through *EBF* and continued back to meet the axis *CD* at the point *O*.

The curve *OEBF* was then assumed as a graphical history of the air speed on distance, the part from *C* to *A* referring to the collector and the part from *A* to *D* to the diffuser. The curve *OE* for an axial distance *OC* may then be assumed to refer to the history of the velocity of the air outside the collector and during which it is accelerated from the low or inconsiderable speed of return to the speed of 15 m.p.h. at *C*. It should be noted that the curve *OEBF* was laid in as a smooth continuous curve showing easy and gradual acceleration and

from the assumed origin at O_1. A similar construction for the other points gives the curve $E_1B_1F_1$ as the time distribution of the velocity in passing through the tunnel, apart from the experiment chamber. The form of this curve was again considered by the eye, and between the two a final form of curve for velocity on distance was chosen. Again neglecting change in density, these values of the velocity serve to determine the cross-sections of the tunnel as compared with the section at the throat, 5.5 ft. diameter.

Again considering the collector as a large nozzle into which the air is flowing as the result of a reduction of pressure in the experiment chamber and under the well-known laws for the flow of gases, it was found that the changes in density involved were too small to introduce any sensible change in the law of the distribution of velocity for the section areas assumed, or in the section areas for the velocities as shown by the accepted curve.

In this general manner the curves for the two parts of the tunnel were determined. Actually, of course, the width of the experiment chamber intervenes at the throat point *A*, but this fact does not introduce any difference in the character of the curves as showing the presumptive history of the wind velocity on its way along the collector and the diffuser.

At the end of the diffuser and just before reaching the propeller exhaust fan, the form of the diffuser was slightly modified by bringing the curve of cross-section areas in slightly so that the areas are sensibly uniform just before reaching the fan location at the exit end of the diffuser.

In order to secure the desired uniformity in flow at the entrance into the chamber from the mouth of the collector, a honeycomb structure was built in the delivery end composed of hexagonal cells 3 in. diameter and 10 in. long (Fig. 6). These are of builders' roofing tin and are soldered at the edges, forming a stiff and true structure with thin walls and presenting the minimum resistance to the flow of the air.

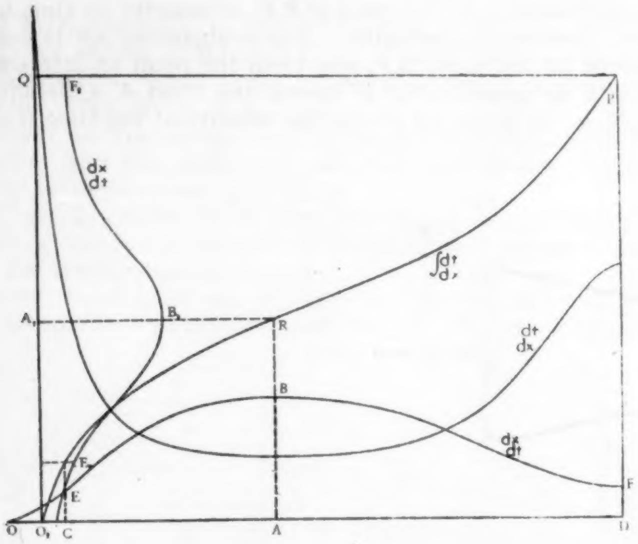


FIG 5.—METHOD OF DEVELOPING WIND TUNNEL FORM

In order the better to collect the air at the entry end of the diffuser, an inward-projecting flaring rim was fitted as shown in the drawings.

PROPELLER FAN

The exhaust fan at the outer end of the diffuser is of the propeller type, 4 blades, 11 ft. in diameter and with a mean pitch of approximately 5.3 ft. The pitch is distributed on the Drzewiecki system, assuming an advance of 4 ft. per revolution with an angle of incidence of 3 deg. This gives values of the pitch on radius as shown in Table 1.

TABLE I—DIMENSIONS OF FAN PROPELLER

Radius Feet	Pitch Feet	Width of Blade Inches	Maximum Thickness Inches
1.0	4.50	11.0	2.50
1.5	4.60	11.5	2.05
2.0	4.74	11.8	1.66
2.5	4.88	12.3	1.55
3.0	5.05	12.3	1.35
3.5	5.24	12.3	1.25
4.0	5.40	12.3	1.07
4.5	5.56	12.3	.90
5.0	5.72	12.0	.75

The propeller fan is driven through a belt connection from a 20-hp. constant-speed induction motor. Such changes in wind speed as are desired in the program of propeller tests are obtained by changes in the size of the drive pulley on the motor shaft. The general plan of the propeller tests contemplates sensibly constant wind speed for any given run of tests and variable revolutions of the test propeller. This permits a constant motor speed for the fan propeller for any given run of the model propeller with variations in slip and other conditions secured by varying the revolutions of the model propeller. In the actual tests as reported in Part II of the original report, the runs were made approximately at two wind speeds, approximately 30 m.p.h. and 40 m.p.h., and corresponding approximately to 220 and 310 r.p.m. of the fan propeller. In order to secure extreme slips, with the power available, certain propellers were also run with a wind velocity of about 20 m.p.h.

IMPORTANT DETAILS OF CONSTRUCTON

The form of the collector and diffuser tubes was determined by circular frames made by nailing up a double ring of 7/8-in. board segments, sawn to the proper curvature on one side, thus forming a strong ring of wood 1 3/4 in. thick. These rings were then fastened to uprights made of 2 by 4-in. scantling spaced about 2 ft. between centers and so adjusted vertically as to line up with the axis of the tunnel about 8 ft. 9 in. above the floor of the room. These circular rings, spaced out in this manner and each of appropriate diameter, give thus a series of transverse sections of the tunnel. The next step was to run longitudinal battens 7/8-in. thick by 2 in. wide along the inside of these rings, spacing them equally around the circumference. These battens were spaced about 6 in. between centers at the small end and 12 in. at the large end. This entire framework, when set up, cross-braced, staved to the building, roof and floor, made a very

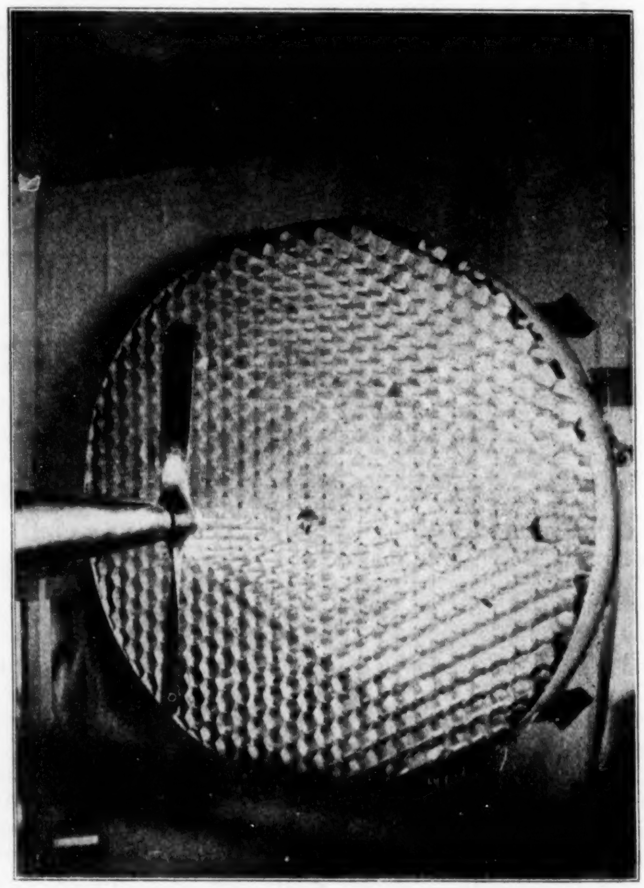


FIG. 6—HONEYCOMB STRUCTURE AT DELIVERY END OF COLLECTOR

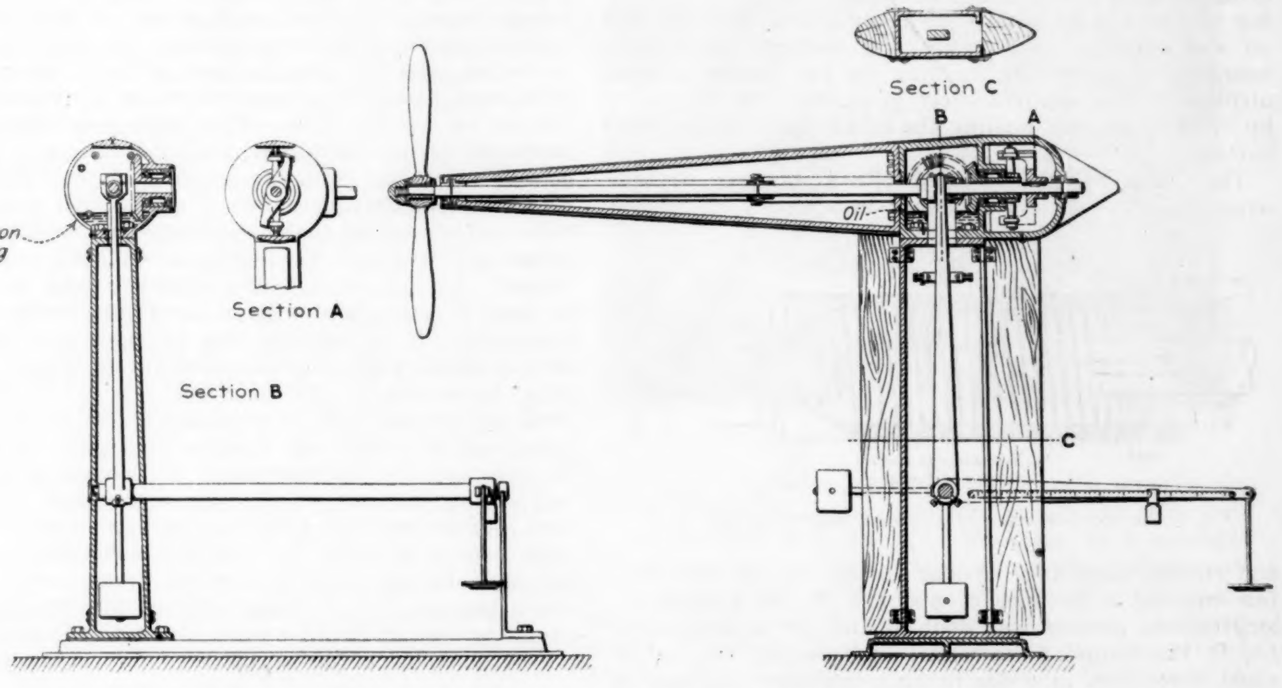


FIG. 7—THRUST DYNAMOMETER AND METHOD OF SUSPENDING PROPELLER IN AIR STREAM

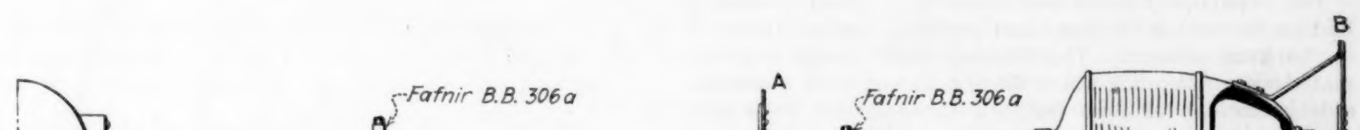


FIG. 8—TORQUE DYNAMOMETER ARRANGED TO MEASURE MOMENT OF MOTOR-SHAFT

stiff and secure skeleton on which to lay the inner covering forming the shell of the tunnel itself. This covering was of a good quality of heavy cotton sheeting laid on and stretched with care and secured along each longitudinal batten by running on the inside a small airplane batten approximately $\frac{1}{4}$ in. thick at the center by $\frac{3}{4}$ in. wide, thus holding the fabric down on the large battens.

The fabric was then treated with a standard airplane wing "dope" (celluloid dissolved in acetone), varnished

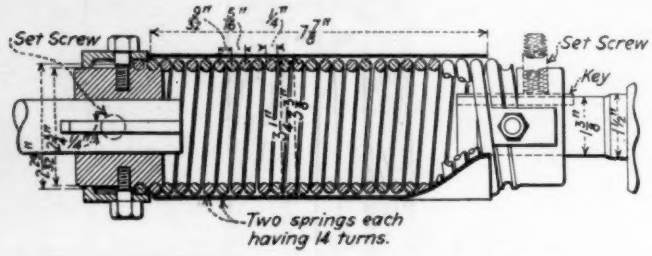


FIG. 8-A—SECTION OF COILED TORSION SPRING

and rubbed down to a smooth finish. At the propeller-fan end for a distance of about 4 ft. the number of longitudinal battens was doubled and for a distance of $1\frac{1}{2}$ ft. the inside of the tunnel was covered with galvanized sheet iron in order to give necessary stiffness in the immediate vicinity of the tips of the blades of the fan. This general procedure gave a tunnel with a smooth, true and fair surface, conforming to the law of cross-sectional areas as determined, and, as later test showed, stable and without sensible vibration or disturbance under the highest wind velocities employed.

The experiment room was made of matched boarding laid on the inside of joists and studding spaced about 18 in. between centers. The highest wind speeds contemplated were not much above 60 m.p.h., and with a reasonable coefficient of flow through the collector tube this would require a reduction of pressure in the experiment room not much exceeding 10 or 12 lb. per square foot. This is a very moderate load, and no trouble was experienced in carrying it with ordinary framing covered with the matched boarding as indicated. To give light in the experiment room, two window sashes were fitted and the glass was reinforced on the inside with supports, reducing the size of pane to the equivalent of about 9 by 10 in.

The room was made practically air-tight by papering on the inside with heavy builders' paper laid on with a specially heavy paste. For entry and exit an airlock was provided with doors closing on suitable packing strips and fitted with self-adjusting hinges, allowing close contact between door and packing.

SPECIAL EQUIPMENT

The special equipment for propeller testing comprises the following items: Thrust dynamometer, torque dynamometer, revolution counter, air-speed meter.

Thrust Dynamometer

The general arrangement of this apparatus is shown in Fig. 7, on page 233, and will be clear with a minimum of textual description. The general form of the apparatus was so designed as to place the propeller approximately $1\frac{1}{2}$ diameters forward of any sensible obstruction in the path of the air stream, and even here the standard is given a sharp forward and after edge and stream line form in order to minimize any possible reaction on the propeller itself.

The propeller is carried on the forward end of a shaft $1\frac{1}{4}$ in. diameter, which runs in ring-oiling cylindrical bronze bearings. This shaft is driven without longitudinal constraint through a yoke at the rear end having hardened steel flat longitudinal surfaces which engage with small ball-bearing steel rollers on a companion yoke carried by a bevel gear. This bevel-gear runs on ball bearings outside the hub, which is bored to provide freedom from contact with the propeller-shaft. The 7.5-hp. direct-current driving motor is placed well over at the side, entirely out of the wind stream and drives the propeller-shaft through bevel-gearing and the yokes mentioned. In this manner the propeller-shaft is subject to angular compulsion only so far as the motor drive is concerned. It is entirely free to move longitudinally, as may be determined by the other forces in play. These other forces are the pull (or thrust) due to the propeller itself and some form of weighing or measuring device calculated to control and balance such pull (or thrust). To this end the propeller-shaft is furnished with two ball-bearing thrusts which connect through hardened-steel knife-edges with a vertical lever as shown in Fig. 7. This lever is attached to a shaft which extends outside the standard, well beyond the wind stream, where it carries a horizontal scale beam with suitable weights. An adjusting weight in the casing serves to adjust the center of the device for sensitiveness of movement, and

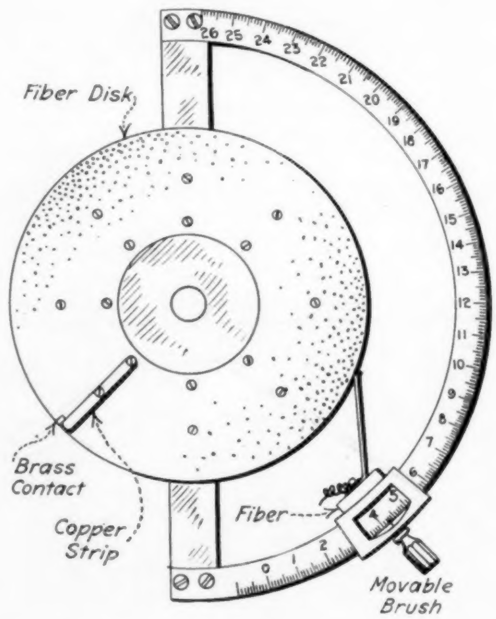


FIG. 8-B—DISK B AND GRADUATED SCALE FOR MEASURING TORSION

suitable stops control the range of travel of the vertical arm, and hence the horizontal travel of the propeller-shaft.

This arrangement furnishes a sensitive and reliable means of measuring longitudinal forces developed by the propeller and without constraint due to the motor drive. The frictional forces involved when the shaft is in rotation are so small as to be quite negligible in comparison with the propeller forces involved, but even these, small as they are, may readily be eliminated by suitable calibration.

Torque Dynamometer

The general arrangement of the torque dynamometer is shown in Fig. 8. The motor-shaft is extended to the

casing of the thrust dynamometer stand and is cut for the insertion of a special coiled spring (Fig. 8-A. The motor-shaft torque is then measured by the torsion of this spring. To measure this torsion two fiber disks are fitted to the shaft, one on either side of the spring, actually at *A* and *B*, as shown. These disks carry a narrow metal strip on the edge to serve as an electric contact. The contacts are electrically connected to the shaft and hence to each other. A fixed brush resting on the face of the disk *A* is carried by the dynamometer frame. From this brush is led an electric conductor, first to a battery, then to a telephone receiver, and then to a second brush mounted over the disk *B* (see Figs. 8-B and 9). It is clear that if the contacts on the disks pass under the brushes simultaneously the circuits will be closed for the instant and a click will be heard in the telephone receiver. If they do not pass simultaneously, the circuit will not be closed and no click will be heard. Suppose, then, with no torque on the shaft, the brush carrier at *B* is so adjusted as to give simultaneous contacts and a click in the receiver is heard; then with a load thrown on and a resultant torque the spring will twist, the contacts will no longer be simultaneous, and no click will be heard. Then the brush-holder at *B* can be moved around to a point where the contacts will again be simultaneous and the click will be picked up again. Obviously the angle through which the movable brush holder is carried in order to thus compensate for the twist in the drive spring will measure the angle of spring torsion, and this by suitable calibration, as described later, is readily translated into torque moment.

Revolution Counter

The revolutions are counted by the movement on a drum, geared down by double worm-gear drive and so adjusted in diameter that 1 in. of travel on the face of a

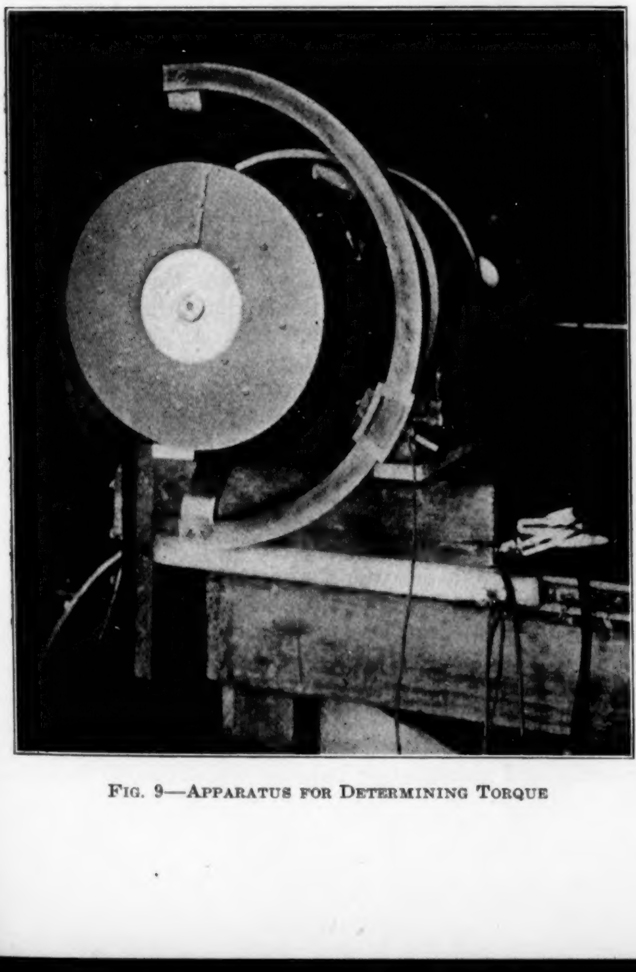


FIG. 9—APPARATUS FOR DETERMINING TORQUE

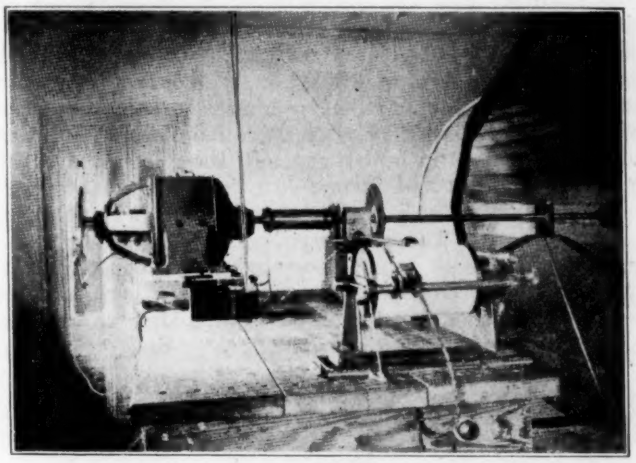


FIG. 10—REVOLUTION COUNTER (IN FOREGROUND)

paper strip carried on the drum is just 50 revolutions. The drum is appropriately mounted on a frame with pencil carrier and with electric connection to a seconds-beating pendulum. In operation the drum revolves and the pencil resting on the paper draws a line with jogs introduced by the click at second intervals. A given length of time is thus translated into revolutions and the revolutions per minute thence readily determined. A general view of this apparatus is shown in Fig. 10.

Air-Speed Meter

The ultimate measure of air speed was based on the pitot tube. The type employed is that made by the American Blower Co. and known as the A. B. C. tube. In this type the static pressure is indicated through air holes of about 0.02-in. diameter. Exhaustive test for this pattern of tube has indicated that its coefficient may be taken as sensibly unity, and for all experimental work such coefficient has been assumed. It is, however, not convenient to make, in connection with each observation, a series of pitot tube readings on air velocity, and to avoid this a series of careful determinations were made between the depression (difference in pressure outside and within the experiment room), considered as an air-pressure head, and the resulting velocity at the propeller location within the experiment room. This relation measures in effect the efficiency of the collector and honeycomb baffle, viewed as an orifice. The relation thus developed was as follows:

$$\text{Velocity head} = 0.876\ (P_1 - P_2)$$

where P_1 and P_2 denote the pressure heads without and within the experiment room.

The lost energy indicated by the difference between this and 100 per cent is distributed presumably among the following items:

(1) Friction resistance of collector surface.

(2) Resistance due to honeycomb baffle.

(3) General turbulence.

(4) Some slight spreading of the stream at the propeller location, with lower velocity as compared with that just at the delivery end of the collector.

With this relation between air velocity and experiment chamber depression assumed, a sensitive pressure indicator showing the pressure head between the experi-

ment chamber and the surrounding room serves as an instantaneous air-speed indicator.

Such pressure indicator is secured by the device shown in Fig. 11 and weighing to 0.01 lb. per square foot. The device as shown consists of two manometric-cells carried each on opposite ends of a sensitive balance. The lower ends of the cells dip under coal oil, the space above the liquid being connected in one case to the air in the experiment chamber and in the other to the air in the surrounding room. The zero position of the scale is determined with both cups connected to the outer room. With one connected to the experiment room, the balance becomes disturbed, and the weights added to restore equilibrium furnish a direct measure of the depression

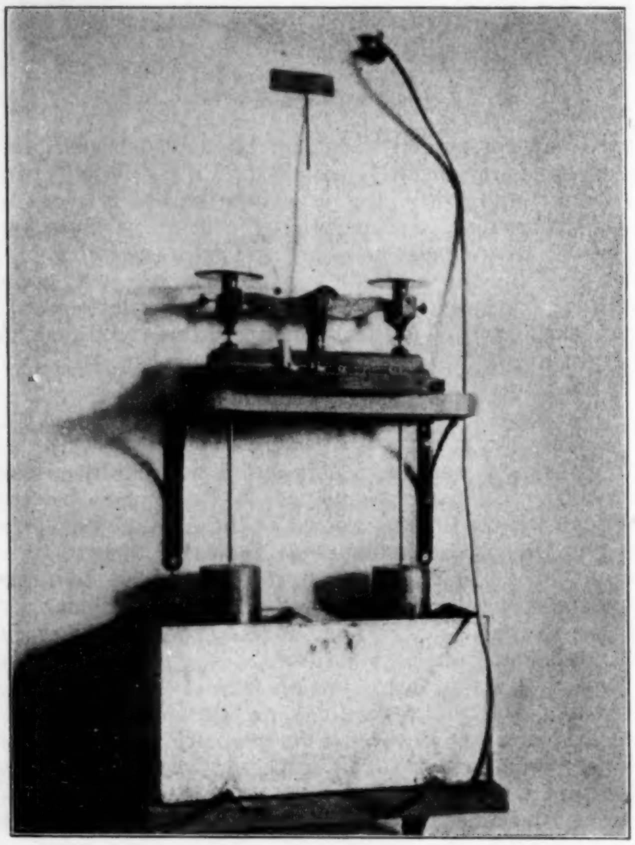


FIG. 11—AIR-PRESSURE INDICATOR FOR DETERMINING AIR SPEEDS

within the experiment room. These indications calibrated against the pitot tube measures of speed give then the direct relation desired between the measure of the depression and the air speed at the propeller position. The weights for the balance were of such mass as to give readings of pressure directly in pounds per square foot. These readings are independent of the fluid used. Coal oil was selected, as it kept the cans wet and there was no variation in the meniscus.

TESTS AND CALIBRATIONS OF APPARATUS

Air Propeller

No matter what the type of air tunnel, the circuit may be considered as closed. If the circuit is complete and such as to hold the air under restraint throughout the entire round, the closed character is evident. If as in the Eiffel type the air is delivered to one end of a room and drawn from the other, the return outside the tunnel may be viewed as through the room. The room may furthermore be considered as of any size, and in the extreme case we may suppose it infinite in dimension, in which case the air may be considered as delivered at one point and drawn in at another.

From this viewpoint the problem is, therefore, that of establishing and maintaining a continuous flow of air in a closed circuit. The energy required will then be obviously the energy dissipated in the circuit. If no energy were so dissipated, the air circuit once set up would continue indefinitely. There is, however, a continual dissipation of energy in the form of turbulence due to surface resistance and unavoidable formation of eddies and irregular turbulent motion. This loss the fan or its equivalent must supply.

In considering the operation of the fan we may most conveniently compare the power actually required at the fan with the kinetic energy in the air flowing through the throat of the circuit. This gives then a comparison between the energy dissipated in the total circuit, including the fan and the kinetic energy in the air at the throat.

Assuming normal atmospheric pressure and temperature in the outside room, and with due allowance for the slightly diminished density at the collector delivery, we find for the kinetic energy at this point the values shown in Table II, third column, while test of actual fan input

TABLE II—POWER REQUIRED BY FAN AND KINETIC ENERGY IN AIR STREAM

Fan, R.p.m.	Wind Velocity, Ft. per Second	Kinetic Energy, Wind Stream, Hp.	Fan, Hp.
215	41.7	3.68	3.32
279	53.8	7.86	6.40
320	61.8	11.95	10.00
336	64.6	13.60	11.70
376	72.8	19.45	16.35
406	78.8	24.70	21.95

showed the values as given in the fourth column. These indicate for the speeds employed a relation given substantially by the following:

Energy dissipated $= 0.86 \times$ kinetic energy of air at throat.

The relation of wind velocity to fan revolutions and of wind velocity to fan horsepower are shown graphically in Figs. 12 and 13, respectively.

UNIFORMITY OF VELOCITY OVER CROSS SECTION OF AIR STREAM

Surveys were made over the cross-section of the air stream in order to determine the variation of velocity in time at any one point and from point to point over diameters horizontal and vertical.

These indicated a mean variation of velocity head on distance of about 2.5 per cent or a mean variation of velocity of 1.25 per cent. The variation of velocity at any one point with time was substantially the same. A pitot tube survey of 20 well-distributed cells of the honeycomb baffle showed, just in front of the delivery plane, a mean variation of velocity head of 0.7 per cent. The time variation of a single cell was similarly 0.8 per cent. These correspond to velocity variations of one-half the above values.

RELATION BETWEEN DEPRESSION WITHIN EXPERIMENT ROOM AND AIR VELOCITY

This relation was based on pitot tube determinations of velocity and manometric balance measures of the dif-

ference of pressure acting as an air head. Numerous determinations of this relation were made at the start of the work and they were repeated daily throughout the tests in order to detect any tendency toward change in this relation. The relation was found practically con-

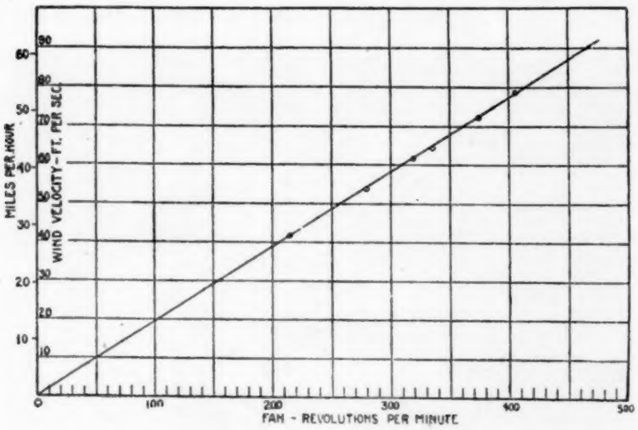


FIG. 12—RELATION OF WIND VELOCITY TO FAN SPEED

stant and as the result of large numbers of determinations was taken as:

$$\text{Velocity head} = 0.876(P_1 - P_2)$$

where P_1 and P_2 denote the pressure heads without and within the experiment room.

It should be noted that when the model propeller is in operation with a velocity sufficient to give a positive slip, and hence an additional accelerating effect on the air, we have in effect an additional fan in the system and hence must expect an increase of velocity of air stream. This effect on the air stream will also be twofold, as follows:

(1) Local and immediately in front of the model propeller, where there will be acceleration of the air as it approaches the propeller.

(2) Outside the immediate local influence of the model propeller where there will be an increase in air-stream velocity due to the greater amount of energy supplied in the circuit and a corresponding reduction in pressure in the experiment room with consequent general increase in the speed of inflow. It was, therefore, important to ascertain whether the general velocity of air stream as indicated by that of the cylindrical shell about the propeller still remained in the same relation to the fall of pressure within the experiment room.

Careful and repeated tests showed that this was the case and it was, therefore, assumed that the combined action of the large fan propeller and the model propeller was to produce a velocity of wind stream in the cylindrical shell surrounding the model, standing in the given and fixed relation to the depression caused in the room by the joint action of the two propellers. This velocity of wind stream then corresponds to the indefinite stream flowing around and outside of the propeller in the case of an airplane in free flight, and is, therefore, to be taken as corresponding to the velocity of flight through the air.

Similarly the local result immediately in front of the model propeller is to be taken as similar to the local acceleration of the air immediately in front of the airplane propeller, causing a local flow of air aft to meet the forward moving propeller.

It is assumed from precedent and from general experience in wind tunnel work that a propeller model 3 ft. in diameter could be properly run in a wind stream 5½ ft. in diameter without sensible disturbance at the boundaries of the stream and hence with sensibly the same result as though in an indefinite stream.

Relation Between Diameters of Wind Stream and of Modern Propeller

The experimental examination of this question was approached from three different directions, as follows:

(*a*) Successive reduction of wind-stream diameter with comparative study of thrust and torque coefficients.

(*b*) Pitot tube survey of wind stream with model propeller in operation, with special reference to distribution of velocity in the cylindrical shell outside the tip circle of the propeller.

(*c*) Comparison of thrust and torque coefficients for four sizes of propellers of successively increasing diameters.

The results of these three examinations may be briefly indicated.

The diameter of the wind stream was reduced by 6-in. steps by blanking over the delivery end of the collector with suitable flat annular rings. This had the effect of closing off an outer zone of cells of the honeycomb baffle, leaving the remainder operative. This gave wind streams of diameters, successively, 66, 60, 54 and 48 in., and within which a propeller of 3 ft. diameter was run. The results were then reduced to the form of thrust and torque coefficients by assuming, at equal values of V/ND (velocity of air $\div$ [revolutions $\times$ diameter of propeller]), a force variation with the square of the speed.

The torque and thrust coefficient curves thus derived give the following indications: The torque and thrust of the 3-ft. model in wind streams of 5 ft. and 5.5 ft. in diameter are sensibly identical. For a wind stream 4.5 ft. diameter the torque and thrust were about 2.5 per cent greater than for the wind streams of 5 ft. or 5.5 ft. diameter.

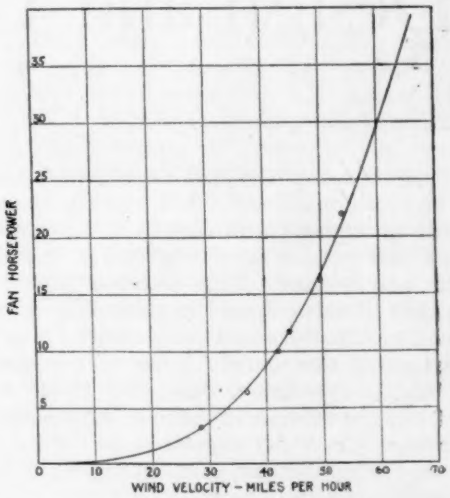


FIG. 13—RELATION OF WIND VELOCITY TO FAN HORSEPOWER

For a wind stream 4 ft. diameter the torque and thrust were 6 to 7 per cent greater than for the wind streams of 5 ft. or 5.5 ft. diameter.

With the model propeller in operation and throwing aft a slip stream of pronounced velocity, the wind stream

across the entire section forward of and about the propeller was subjected to survey by pitot tube. The results indicated a relatively abrupt break in the influence of the propeller close about the tips of the blades, and that the size of the slip stream proper at and just in advance of the propeller was practically determined by the diameter swept by the tips of the blades. The velocities in the cylindrical ring lying outside the blade tips were also compared with the depression within the chamber and found to agree as previously stated. These tests indicate that the special influence of the propeller in disturbing the distribution of velocities through the wind stream extends to but a slight distance beyond the circle swept by the tips of the blades. The indications of this test, therefore, support fully the anticipated relation between diameter of propeller and of wind stream.

As a final test in regard to this important question, four propellers of diameters, successively, 30, 36, 42 and 48 in., and similar geometrically, were tested out in regular course and the results reduced to thrust and torque coefficients by assuming, at equal values of V/ND, a force variation with the square of the speed and with the square of the diameter. The results of these tests indicate substantially the same values of the coefficients for the same value of V/ND for all four propellers. This indicates apparently that the diameter of the propellers might have been increased to 42 in., or possibly even to 48 in., and run in a wind stream of diameter 66 in. without sensible departure from the conditions in an indefinite stream.

As a matter of fact, the values of the coefficients for the diameters 30, 42 and 48 in. lie most satisfactorily on a continuous smooth curve. Those for the diameter 36 in. lie slightly above. This slight variation is apparently due to some slight departure in geometrical similarity between the propeller for 36 in. diameter and the other three.

In any event, these results, together with the others noted above, seem to justify fully the use of the propeller models of 36 in. diameter in the wind stream of 66 in. diameter.

Calibration of Torque Dynamometer

The torque dynamometer was calibrated as shown in Fig. 14. A Prony brake was attached to the shaft at

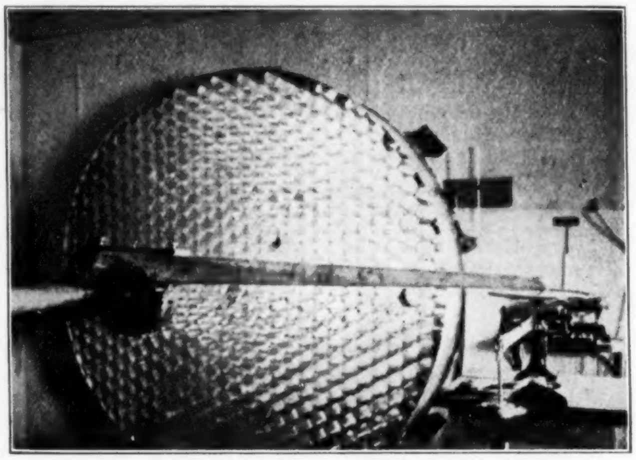


Fig. 14—Apparatus for Calibrating Torque Dynamometer

the propeller position. A load was applied and the corresponding yield of the spring was noted. These tests were made at various speeds, and loads were applied varying from zero to the full capacity of the driving motor. These calibrations were conducted daily throughout the tests in order to detect any change in the ratio of spring yield to moment in pound-feet. The ratio was found to be practically constant for all speeds and loads.

Design and Use of Wind Tunnels

By J. R. Pannell, A. F. Ae. S.

It has long been realized that experiments in the laboratory on small models afford, in certain cases, a means of obtaining, cheaply and rapidly, information on the behavior of the actual structure under the conditions in which it is to be used. This plan has been adopted in many branches of science, and in none to a larger extent than in naval architecture and aeronautics. The problems to be investigated are usually those connected with the motion of bodies through a fluid, but if we accept the principle of relative motion we have an alternative method open to us for our model experiments. We can, if we wish, reverse the conditions, and set the fluid in motion, the model remaining stationary.

Generally speaking, one plan has been adopted in naval architecture and the other in aeronautics. In the former case, models are towed through water in a ship tank, while in the latter they are placed in a tube through which air is passed. One difficulty in the case of the moving fluid is to estimate the velocity, and, mainly for this reason, a certain amount of experimental work has been carried out in air by moving the body on a whirling arm. This plan was invaluable in providing a standard anemometer calibration, but, this done, there is only an extremely small amount of work which cannot be carried out more satisfactorily in the wind tunnel. The stationary model offers many advantages, particularly in connection with measurements of the forces acting upon it, and the method might be applied with advantage in experiments on ship models to a greater extent than has hitherto been the case.

The application of model results to the actual structure is often a matter of considerable difficulty, but as the amount of information obtained in aeronautics increases it appears probable that the change of the coefficients in passing from model to full scale—which is small in the majority of cases—will soon be known with considerable accuracy. In these circumstances the value of model experiments becomes high, and it appears that the performance of an airplane can be predicted by this means with considerable accuracy.

From a paper delivered before Aeronautical Society of Great Britain.

It must be clearly understood, however, that the value of model experiments is entirely dependent on their accuracy. Changes in parts of an airplane often cause appreciable differences in the performance, though the parts themselves may be so small as to be difficult of reproduction at all on a 1/12th-scale model. It has been stated that in a certain type of airplane the substitution of streamline for circular wires caused an increase of 10 m.p.h. in the speed, yet only the highest experimental accuracy would enable the difference to be measured on a 1/12th-scale model.

Again, some experiments were carried out on a 1/25th-scale model of a large biplane in order to determine, among other things, the angle at which the tail plane of the machine should be set and the position of the rudder hinge, in order that the rudder should be just stable. The model experiments determined the required angle of the tail plane and showed that the rudder would be neutral if the hinge were moved forward a few thousandths of an inch. The determination of the latter quantity represented the extreme limit of accuracy, but it was found in the actual machine that the rudder was rendered stable by a forward movement of the hinge of an inch or so. Moreover, this machine was one of the earliest of its kind, and it was feared that an error in the setting of the tail plane (which was based on the results of the model experiment) might give rise to forces on the machine greater than those which could be exerted by the controls. The machine, however, carried out its trials without accident, and its prototype is today one of the most successful British bombers. If it be conceded that the model experiments prevented accidents to only *one* machine, the saving in mere money was sufficient to carry on the work of the entire aeronautical department of the National Physical Laboratory for many months.

Types of Wind Tunnels

When the author was invited to prepare a paper on The Wind Tunnel, he was impressed by the fact that such a general title could only be justified if a description of all the tunnels in which satisfactory experiments had been carried out was included. An attempt has therefore been made to describe briefly the more important tunnels of the world, as far as they are known to the author, the greatest attention being paid to those in which results of obvious value have been obtained. The author's actual experience is, however, limited to the tunnels at the National Physical Laboratory, and the paper must be regarded as mainly a description of that type. It is difficult to avoid bias in favor of apparatus with which one is familiar, but the author believes that this type of low-resistance tunnel in which the air is drawn from a large reservoir, is unequaled for accuracy and rapidity of operation. This view was supported by Lieut. J. C. Hunsaker of the United States Navy, who, after a tour of the principal aerodynamical laboratories of the world, recommended the erection at the Massachusetts Institute of Technology of a 4-ft. tunnel* which in all the essential details is an exact copy of those at the N. P. L.

Considerable progress has been made since the apparatus and methods described in this paper were in use, but the exigencies of the present situation forbid the publication of any further details.

It will be convenient to group the tunnels under the countries to which they belong, and we may commence with the one which perhaps did more than any other in the early days of aviation toward the development of practical types of airships and airplanes.

Early Work in France

A small wind tunnel was erected at the military establishment at Chalais-Meudon, which was in charge of Colonel Renard, as long ago as 1877, and constitutes the earliest tunnel known to the author. It was 13 ft. long, and had a diameter of 2½ ft. A considerable amount of work appears to have been carried out on models of airships, but the results were regarded as confidential, and were not published.

A very extensive laboratory was founded in 1911 by M. Deutsch de la Meurthe at St. Cyr. It includes laboratories, workshops, administration building, several wind tunnels, and an open-air track upon which runs an electrically-driven carriage. Experiments are made on this carriage with full-size airplane wings, and it is by this work that the St. Cyr Laboratory is most generally known.

No details of the tunnels are available, but the form is understood to be circular, with the balance situated underneath the tunnel.

A large amount of experimental work has been carried out in the laboratory of Eiffel, situated in the Champ de Mars, Paris. The laboratory was constructed about 1910, and contains a circular channel nearly 5 ft. in diameter, in which experiments were made in continuation of those made with falling plates on the Eiffel Tower. The characteristic feature of the tunnel is that the experiments are made in an hermetically sealed room, in which the pressure is equal to the static pressure in the tunnel. The air stream crosses this room without any solid boundary, and it is stated that larger models can be used than is the case if the stream is confined within rigid boundaries, no sensible eddies being set up. The length of the chamber is 12 ft., and a conical receiver projects slightly into it on the outlet side.

A balance is provided for measurement of lift, drag, and moment, the observers sitting on a platform above the free stream.

A 65-hp. motor was used, and a speed of 65 ft. per second attained. Several anemometers of the pressure-head type were employed, and compared with the drop of pressure in the closed chamber. The velocity calculated from this pressure difference by the formula $V^2 = 2gh$ was 1½ per cent higher than that given by the pitot tube.

A new laboratory was opened in 1912 at Auteuil. The tunnel is constructed on exactly the same principle as the earlier one, but the diameter has been increased to 6½ ft. The air is led into the test chamber by a reducing cone whose diameter changes from 13 to 6½ ft. in a length of 11 ft. The stream leaves the test chamber by a bell-mouthed opening and passes to the "discharger," which is a cone increasing from a diameter of 6½ to 11 ft. (which is the diameter of the fan) in a length of 30 ft. This design is stated to be very efficient, as the air reaches the fan at a low velocity and at a pressure little above that of the hall into which it is delivered. A 50-hp. motor is provided, and a maximum speed of 100 ft. per second is attained.

Experiments have been carried out in these tunnels covering a wide range of subjects, including the determination of forces and moments on aerofoils, complete models, and bodies, pressure-plotting experiments, and tests on series of propellers.

The convenience of an arrangement which enables the

*Described in the Smithsonian Miscl. Co., Vol. 62.

observers to be placed in the sealed test chamber is no doubt great, but it is open to question whether the accuracy of results obtained in this free current is as high as those obtained by the more generally accepted methods.

It has been shown that an error of 0.2 deg. in the assumed wind direction would cause an error of 6 per cent in the value of the drag of an airplane model.

Developments in Italy

The principal aerodynamic laboratory in Italy is that of the Brigata Specialisti. It is situated near Rome, and is under the charge of Major Crocco. The apparatus includes a wind tunnel in which elaborate precautions were taken to secure uniformity of flow. The air was forced by the fan into a closed chamber, where the velocity was reduced and the pulsations partly damped out. It then passed to another chamber larger than the first, from which it entered the experimental tunnel, which was 2.5 ft. square. Several layers of gauze were introduced, and the flow was stated to be satisfactorily uniform to within a short distance of the wall. The model was supported on the balance just outside the end of this tunnel, so that at the section of the stream at which the experiments were made there was no solid boundary.

Several balances were in use, that provided for the most accurate measurements being supported on the surface of a vessel of water. The principal part of the wind force was balanced by weights attached to a cord passing over a pulley. Records of the movement of the balance were obtained by means of additional apparatus in which electric sparks were passed through specially prepared paper.

In 1912 the laboratory was reorganized under the title Te Stabilimento di esperienze e costruzione Aeronautiche del Genio, and a new wind tunnel of an entirely different type was erected. This tunnel is 6½ ft. square and 22 ft. long, the air current being produced by a centrifugal fan, belt-driven from a 30-hp. electric motor. The balance is placed in a sealed test chamber, there being a gap of about 3¼ ft. at the position at which the experiments are made. The method of test is thus similar to that of Eiffel, except that the length of the "free" stream in which the measurements are made is much less. The test room is divided into two parts, the upper of which contains the balance and its observer, while in the lower is placed the manometer and other instruments. The speed of the air current can be regulated from this chamber by opening or closing shutters on the intake side of the fan.

Two anemometers are used, one situated upstream of the test section, and another placed near the outlet of the tunnel. The uniformity of the flow is improved by the introduction near the fan of a layer of gauze and a honeycomb, and it is stated that over a period of one or two minutes (the time required for an observation) the flow can be kept sufficiently steady. The range of velocity available is from about 7 to 52 ft. per second. Experimental work of considerable value had been carried out in this laboratory until the year 1914, but information as to the results obtained since then is not at present available.

Experiments in Germany

The principal aerodynamic laboratory in Germany was that at Göttingen, of which Prandtl was in charge. The tunnel is of the inclosed type, in which the air circulates continuously round an approximately rectangular path. The test section of the tunnel is 6½ ft. square, but if high speeds are required an octagonal liner can be fitted, reducing the diameter to about 3.3 ft. Guide blades are provided at the corners and a honeycomb and gauze screens are introduced to secure uniformity in the flow. To this end also the walls of the honeycomb are made double, so that any cell can be partly closed by bending one of the walls across it. The gauze is also rendered finer when necessary by painting.

The arrangements for the measurement of forces are unique, separate balances being provided for lift and drag, a total of four being required for the complete investigation of forces and moments. The model is suspended on wires and is restrained in a horizontal plane by two wires at an angle of 120 deg. to each other. One of these wires is fastened to the wall of the tunnel, while the other passes through it and is attached to the drag balance. The drag is calculated from the increase in tension of this wire when the air current is started.

Four supporting wires are brought to a light rod, placed along the wind direction, from which the model is suspended, but it appears to the author preferable to attach the wires to the model directly, as in the case of a low resistance form the flow has been found to be very sensitive to small obstructions. This modification may perhaps have been subsequently introduced. Each pair of wires is taken to a balance above the tunnel for measurement of lift, and the fourth balance is used in obtaining rolling moments.

The velocity is measured by a kind of pitot tube with an inclined-tube alcohol manometer. An automatic regulator is provided to maintain a constant speed. This regulator consists of two bell jars, hung, with their lower ends under water, from a balanced arm. One jar is connected to the tunnel immediately in front of and the other immediately behind the propeller, a pressure difference proportional to the square of the wind speed being thus obtained. The speed is set to the desired value by the regulating resistances and a weight on the regulator balance set to a position marked upon it for the required speed. A change of speed now causes the balance arm to move over to one stop operating a resistance in the field circuit of the motor. The stops are also mounted on a swinging arm whose motion is damped by a vane moving in a fluid. This latter device reduces "hunting" due to over-regulation.

An electric motor drives the fan, a maximum speed of 33 ft. per sec. being attained in the 6½ ft. tunnel and 55 ft. per sec. when the section is reduced to 3.3 ft.

For several years before the war the work carried out in this tunnel dealt mainly with the resistance of streamline bodies, including measurements of pressure distribution. Experiments have also been made on the resistance of spheres, and to a limited extent on airplane models, though the latter branch of study has doubtless been extended recently.

Developments in America

A wind tunnel was erected in an aerodynamic laboratory at Washington in 1901 by Mathilath. The section was 6 ft. sq. and the length 40 ft. The current was produced by a fan 5 ft. in diameter driven by a 12-hp. electric motor, a maximum speed of 40 ft. per sec. being attained.

It was provided with a balance for measurement of lift and drag, and with a torsion balance.

This tunnel was used by Zahm in 1904 for his experiments on the skin friction of flat boards. The method

adopted was to suspend the boards by wires from the roof of the laboratory and observe their displacement under the wind forces.

No complete description of this tunnel has been available, but it appears to be of a satisfactory type. As far as the writer is aware, however, no important work has been carried out since that of Zahm.

A tunnel of the N. P. L. pattern has recently been erected in the Massachusetts Institute of Technology.

A large tunnel is installed at the Washington Navy Yard. It is of the closed-circuit type, the dimensions of the working section being 8 ft. square and 33 ft. long. It is fitted with a honeycomb at the entrance to the working section, some of the cells being closed to improve the uniformity of the flow, which is said to be within 2 per cent of the mean. The balance and motor control-board are situated above the tunnel, the balance being similar to that used by Eiffel.

The current is produced by a 50-hp. electric motor, driving a centrifugal fan; a maximum speed of 75 m.p.h. can be attained, but considerable heating of the air takes place at this speed and tests are usually carried out at 40 m.p.h. The velocity is measured by pressure tube anemometers, which have been calibrated against the N. P. L. standard.

Developments in Russia

The principal experiments in aerodynamics which have been made in Russia are those conducted at the Institute at Koutchino, near Moscow,* under the superintendence of Riabouchinsky. The equipment includes a straight tunnel of circular section 4 ft. in diameter and about 48 ft. long. The air is drawn through the tunnel by a fan, which is belt-driven from an electric motor, and is returned through the building in which the tunnel is placed. A maximum speed of about 20 ft. per sec. is attained, and a balance, whose axis is horizontal, is provided for force measurements.

Experiments in this tunnel have, on the whole, been of scientific rather than of an engineering character, and include observations on the resistance of spheres, autorotation of plates, resistance of square plates, etc. The reports issued include several relating to propellers.

Developments in Great Britain

The principal aeronautical laboratory for model experiments in England is at the National Physical Laboratory, and comprises five wind tunnels, inclosed whirling arm, small water tunnel, and two wind towers. A 4-ft. air tunnel is in use at the Royal Aircraft Factory in connection with the full-scale experimental work, which differs from those at the N. P. L. in that no distributor is used. The tunnel is located in a large airship shed, and no disturbance is caused at the intake because of the eddies from the fan. The same modification is applied in the tunnel at the Royal Naval Air Station at Kingsnorth, which has a section 6 ft. (horizontal) by 4 ft. In this case a four-bladed fan driven by a gasoline engine is placed in the open air and the current is drawn through the tunnel from an airship shed. A speed of 100 m.p.h. is attained.

A small wind tunnel was installed at the East London College in 1911, and is still in use for certain experiments. This has been replaced by a 4-ft. tunnel, which is a copy of the National Physical Laboratory tunnels except that it is constructed of iron. The author is indebted to Norman Piercy, who is in charge of the tunnel, for the following particulars. The balance differs from those at the N. P. L., the axis being horizontal, and includes one novel feature. Considerable trouble had been experienced with the pivot upon which the balance of the earlier tunnel was supported, and at the suggestion of Prof. Macgregor Morris this pivot was discarded in favor of a metal diaphragm whose plane is vertical, and to which the balance is rigidly attached. The diaphragm is bolted between two stout metal rings, the motion of the balance being resisted by the flexual rigidity of the diaphragm.

With the diaphragm at present in use the limit of sensitivity is about 1/6000th of a pound. Greater sensitivity could be obtained by the use of a thinner diaphragm, but one objection to the method appears to be that the sensitivity cannot be readily changed in passing from one test to another.

The angle of incidence is varied by rotating the balance in a bearing the outer part of which constitutes the attachment to the diaphragm. The lift forces are measured by weights hung on the beam of the balance; the drag forces are transmitted by a horizontal bell-crank to another bell-crank whose plane is vertical, and upon the horizontal arm of which the measuring weights are hung.

The maximum velocity that can be attained at present is 50 ft. per sec., but sufficient power is provided to attain 90 ft. per sec. when the driving arrangements have been modified.

There are many other tunnels in use in this country, but the author believes that the more important of them are copied from those at the National Physical Laboratory.

Tunnels of the National Physical Laboratory

The first N. P. L. air tunnel was constructed in 1902. It was designed by Dr. T. E. Stanton, F.R.S., and used by him for the experiments on the air resistance of plane surfaces. It consisted of a vertical tube 2 ft. in diameter, through which the air could be drawn downward by a fan placed at its lower extremity. The air was delivered into the large engineering shop so that practically still air was continuously supplied at the intake of the tunnel. It is therefore not surprising that the steadiness of the flow was comparable with that of the newer tunnels. A balance was provided for measurement of forces along the wind only.

For measurement of velocity Dr. Stanton devised a pitot and static head, of which the present laboratory standard is the outcome; the only essential difference is that, for convenience, the tubes are now concentric, instead of some two inches apart, as in the original form. Much useful work was carried out in this tunnel, and it is in service at the present time.

The Advisory Committee for Aeronautics was formed in 1909, and an extensive program of work was laid down. The need of additional apparatus was at once felt, and it was decided to erect a new tunnel. This tunnel had its axis horizontal. The total length was 20 ft. and the working tunnel, 4 ft. square, was inclosed in a return tunnel 8 ft. square. The air current was set up by a 6-ft. Sirocco fan, driven by a belt from an electric motor, which drew the air through the working portion of the tunnel and delivered it to the return tunnel. Guide blades were provided at the fan outlet to correct the rotary motion of the air, and layers of wire gauze were introduced at the inlet to the test tunnel in order to improve the uniformity of the flow across a section. The velocity was measured by a pitot tube and Chattock tilt-

*Koutchino Bulletin Fasc. I., 1916.

ing manometer, and reached a maximum value of 30 ft. per sec.

The balance was constructed in such a manner that simultaneous observations of lift and drag could be taken. The axis of the balance was horizontal, and for measurements of lift turned in ball bearings about a horizontal axis normal to its length. These bearings were carried in a fitting suspended on fine steel wires, allowing rotation of the balance through a small angle about a vertical axis for measurements of drag. The latter motion was transmitted to a right-angled bell-crank whose plane was normal to that of the main balance arm. The horizontal arm of this bell-crank constituted the drag beam upon which were placed weights to balance the wind forces. An oil dash-pot damped the oscillations of the two beams. One observer observed the reading of the drag beam and another regulated the speed of the air current and observed the reading of the lift beam.

This tunnel was in use till the year 1912, and the whole of the experiments carried out up to that date were made in it or in the 2-ft. vertical tunnel. The 4-ft. tunnel was not entirely satisfactory, the flow being too unsteady to allow experiments to be carried out to the high order of accuracy desired. This result was mainly due to two causes; in the first place the fan was of the centrifugal type, which is now known to be unsuitable for this purpose. There was found to be large pulsations in the pressure, a feature that appears to be common to fans of this kind. The second cause, which was of less importance, was that the air was returned to the intake of the tunnel in a disturbed condition.

It was accordingly decided to undertake a complete investigation into the conditions that affect the uniformity of the flow.

The design of the N. P. L. tunnels in their present form was based on these model experiments, of which an account is given in the 1912-13 Report of the Advisory Committee for Aeronautics. The success of the experiments can be judged from the fact that the latest of these tunnels was made almost an exact copy of the first, the only modifications being of minor importance, which were suggested by experience as likely to facilitate the taking of observations or to improve their accuracy. The criterion by which the merits of the various arrangements was judged was the nature of the variations of pressure difference in a pitot and static tube of the standard N. P. L. pattern. The pressure was recorded by a special form of photographic gage which was constructed for these experiments.

An exhaustive series of experiments was made with models, and the following conclusions were finally arrived at: (1) The air current should be produced by a fan of low pitch. (2) The air leaving the fan should pass into a distributor slightly larger than the fan and from three to four diameters long. The air should escape from the distributor through tubes of appreciable length (actually about 1.2 in. for the 4-ft. tunnels), which should distribute the air over as large an area as possible in constant quantity per unit area. (3) The smallest building in which such a tunnel can be housed to give satisfactorily steady flow is one whose dimensions are 6 by 6 by 15 tunnel diameters.

Modern Type of Tunnel

The new (or No. 1) 4-ft. tunnel was constructed on these lines. The tunnel, which has an overall length of about 54 ft., is placed in a building 60 ft. long, 50 ft. wide, with an average height of about 20 ft. This building was the existing engineering laboratory, and was larger than the size laid down by the model experiments. That size was, however, adhered to in constructing the 7-ft. tunnel in view at the time the model experiments were being carried out. The No. 1 four-foot tunnel is provided with a trumpet intake, and a honeycomb is placed in the parallel tunnel, near the entering end. The air passes through this honeycomb to the balance, which is located in the parallel tunnel some 16 ft. from the intake. At the end of the parallel portion a metal expanding piece is fitted, in passing which the section is changed from square to round. The circular part of the tunnel is very short, being just sufficient to house the fan, which is driven by a long shaft from an electric motor supported on the wall at the end of the tunnel. The air is delivered from the fan into the distributor, from which it passes at low velocity to the room.

A glazed door is provided through which models may be introduced, and a trapdoor is fitted immediately over the balance.

The fan has four blades 6 in. wide, and is capable of producing a current of 50 ft. per sec. at 1350 r.p.m. The power absorbed at this speed is 8 hp., of which some 20 per cent is lost in passing the honeycomb.

Regulating resistances are provided, and tests can be made at any wind speed from 20 to 50 ft. per sec.

Types of Balances

The balance for the No. 1 four-foot tunnel is of entirely different design from that of the original 4 ft. It was constructed with a view to carrying out the various complex experiments which were required as the study of the science progressed, and was arranged in such a manner that the interference of the supports with the model under test should be a minimum. Another difficulty was overcome which became more troublesome in the first balance as the size of the models increased, namely, the deflection of the balance, and airship models weighing about 30 lb. have been tested on the similar 7-ft. tunnel balance.

It is proposed to describe the first 4-ft. balance, and to refer later to the changes which have been made in the more recent balances.

The balance consists of two main parts, the lower of which carries the weighing arms and moment apparatus, and the upper of which projects upward through the floor of the tunnel and carries the model under test. The portion of the balance inside the tunnel is shielded from the wind by a guard, which covers also a portion of the spindle. This guard should not, however, approach within about 3 in. of the model; in that position the interference due to it is usually negligible. The upper part of the balance can be turned upon the lower, and the model thus rotated through any desired angle about the vertical axis from outside the tunnel, and without stopping the wind.

The balance is supported on a single steel point resting in a hollow cone. This cone is rigidly fixed to a heavy casting, which is firmly bolted to a cement bed and is perfectly free from contact with the tunnel itself. The steel point is at the intersection of the center lines of the two weighing arms, which are set along and normal to the wind direction.

The balance has three degrees of freedom, and is arranged in such a manner that moments can be measured about the center line of each arm and about the vertical axis of the balance. A jockey weight is provided on

each beam for fine adjustment. The third moment about a vertical axis was measured by means of the torsion of a wire, but this method has now been abandoned. There are two secondary arms placed diametrically opposite to the weighing arms, which carry balance weights, enabling the zero readings of the balance to be adjusted to values which will cover the range of forces to be measured. The arm opposite the lift beam is held by means of a strut and C spring in such a position that the drag beam is accurately along the wind direction. This strut, the point on which the balance rests, the center lines of the weighing arms, and the points of support of the two scale pans, are all in the same horizontal plane when the balance is in its mean position.

A movable weight is provided for adjustment of the sensitivity, and additional weights can be placed on two studs if necessary. A dashpot is provided at the lower end of the balance, and there is a clamp by means of which the balance may be locked in its mean position while adjustments are being made or the balance is out of use. Balance weights are also provided in the upper half, by means of which the center of gravity of the model and the part which rotates with the model may be brought into the vertical axis, about which the balance is turned. This adjustment prevents change of the balance zero when the angle of the model is varied. To prevent a stream of air flowing into the tunnel where the balance enters it, an oil seal has been fixed, which does not in any way interfere with the freedom of motion of the balance.

A somewhat unusual arrangement has been adopted for detecting the departure of the balance from its zero position of equilibrium. The method of setting two cross-wires into coincidence is unsatisfactory, as it is not possible to place the cross-wires close together on account of the allowance necessary for angular motion of the balance during the measurement of moments about a vertical axis.

Parallax is, however, avoided by attaching to the beam a mirror bearing a line, and near it, but on the balance support, a cross-wire. The line and the cross-wire should be parallel, and with the balance in its zero position the cross-wire is adjusted till the line is midway between the cross-wire and its image in the mirror. The vertical distance between the wire and its image may be altered by adjusting the position of the eye, and this plan has been found to give higher accuracy than setting to coincidence. With a model whose weight does not exceed 2 or 3 lb., the balance is sensitive to 0.0001 lb., and much less (0.00001 lb.) for very light models. For the highest accuracy the position of the line on the beam is observed by means of a microscope.

Use of Propeller Balance

The propeller balance* described differs very little from the main balance. It has two weighing arms and is supported on a single point, rotation about a vertical axis being prevented by a strut and C spring in the manner previously described for the main balance. A dashpot is provided to damp out oscillations, and as it cannot be placed farther from the point of support than the roof of the tunnel, it is made to serve also as an oil seal. The speed of the propeller is usually measured by electric signals from a toothed wheel driven from a worm on the propeller-shaft. In experiments in which it is important to maintain the speed at a predetermined value the worm gear is replaced by a commutator which enables a certain number of electric contacts (the number can be varied at will) during each revolution. The pulsating current thus obtained is passed through an electrical frequency meter which gives an instantaneous indication of the speed at any convenient distance from the balance. An electric motor for driving the propeller is carried on the upper part of the balance, current being supplied through mercury cups in order to leave the balance perfectly free. The propeller is driven by a belt passing through a slot in the roof, which allows the whole balance to be turned through an angle of 40 deg. on either side of the position of symmetry. The arm, which projects downward into the tunnel, carries at its lower end ball bearings for the propeller-shaft, the axis of which is coincident with the center line of the tunnel. When the propeller-shaft is along the wind the thrust is measured on the arm parallel to the wind and the torque on the one perpendicular to the wind. When the shaft is inclined to the wind the thrust is still measured on the arm parallel to the propeller-shaft, but the arm perpendicular to the shaft measures the torque and the lateral force on the propeller. These two quantities are determined from observations made when the model is inclined at equal angles on either side of the down-wind position. The torque will be given by the mean of the two readings and their difference will be equal to twice the lateral force.

The balance in this form has been described in the 1913-14 Report of the Advisory Committee for Aeronautics. A large number of experiments have been carried out since that date, and a new balance, the design of which has been modified in several important respects, is now in course of construction for the 7-ft. tunnel.

*Rpt. Adv. Comm. for Aero., 1913-14, p. 291.

Later Tunnels

Since the 4-ft. No. 1 tunnel there have been constructed the 3-ft. and 7-ft. No. 1, in 1914, and in the new aeronautics building the 4-ft. No. 2 and 7-ft. No. 2, in 1916.

The changes in design have been mainly in the balance; those in the tunnel consist in substituting slots for square holes in the distributor, and in turning back the trumpet mouthpiece until it touches the parallel part of the tunnel. The latter step was taken to prevent the formation of vortices, which were found to be formed at the edge of the original trumpet.

The speeds also have been increased, the highest values for the various tunnels being: 4-ft. No. 1, 50 ft. per sec.; 3-ft., 60 ft. per sec.; 7-ft. No. 1, 65 ft. per sec.; 4-ft. No. 2, and 7-ft. No. 2, 80 ft. per sec. In connection with the high speed attained in the two newest tunnels it may be remarked that they are very noisy, and observers usually find it necessary to protect their ears against the very intense vibrations which are set up over about 60 ft. per sec. The author is informed that the Kingsnorth tunnel, in which a speed of 100 ft. per sec. is attained, and in which the fan is driven by a gasoline engine, is much less noisy, and it has been suggested that the vibration of the N. P. L. tunnels are due to the laths of the distributor.

The newer tunnels also have an additional honeycomb between the balance and the propeller. This has the effect of entirely preventing spin of the air due to the rotation of the propeller, but causes an appreciable increase in the resistance of the tunnel. It is probable that guide blades of lower resistance would be equally effective.

Two important changes have been made in the design of the balance—namely, in the apparatus for measuring moments about a vertical axis, and in the method of determining forces along that axis.

The method of measuring vertical force by a rod moving relatively to the balance has been abandoned in favor of the observation of the change in effective weight of the whole balance. No details of the arrangement can be given at present, but it may be stated that on the balance of the 7-ft. No. 2 tunnel forces can be measured with ease to 0.001 lb., which is the 1/100,000th part of the total weight of the balance.

Erecting the Main Balance*

In order that certain conditions essential for accurate working shall be fulfilled, it is necessary that the erection of the balance be carried out with considerable care. The methods which are used for this purpose and to check the accuracy of workmanship will now be described.

Vertical Axis of Rotation

When the balance is arranged for the measurement of moments about a vertical axis the strut which prevents motion about this axis when lift and drag are being measured is removed, and the lower extremity of the balance engages a center, the position of which, in conjunction with the main supporting point of the balance, fixes the axis of rotation. The position of this lower center is adjusted till the axis of the balance is vertical, when hanging weights on the lift and drag beams produces no moment about the axis of rotation. The sensitivity of the moments measuring apparatus renders the method easily accurate to an inclination of the axis of 0.005 deg. The axis of rotation in the N. P. L. tunnels is vertical to an accuracy of about 0.03 deg. The clamp which locks the balance should be arranged to hold it in approximately the same position when the lower center is not in use.

Position of Axis of Upper Part of Balance

It is a matter of considerable convenience in measurements of moment about a vertical axis if the axis of rotation in changing the angle of incidence of the model coincides with that about which moments are measured. The relative positions of these two axes can be determined by fixing a point to the upper portion of the balance, adjusting it to lie in the axis of rotation of the upper portion, and then hanging from it a weight. If the balance remains in equilibrium when supported on a single point, the axis under examination is vertical, and therefore in coincidence with that about which moments are measured. If the balance turns under the weight, it must be returned to its zero position by changing the weights on the lift and drag beams and the process repeated with the point at a new height in the tunnel. Readings of the beams in the two cases enable the position of the axis to be determined.

The N. P. L. balances have been adjusted till the deviation at the center of the tunnel does not exceed 0.01 in.

Angle Between the Lift and Drag Beams

The ratio of the lift to drag in the test of an aerofoil is usually of the order of 17 as a maximum, and a very small error in setting the lift and drag beams at right angles may introduce a serious error in the measurement of drag. It has been shown‡ that in order to avoid errors in the drag measurement exceeding 1 per cent when the ratio of lift to drag is 15, it is necessary that the angle between the beams shall be 90 deg. to an accuracy of ± 0.05 deg. If the linear distances between the scale pan centers and the point of the balance can be accurately determined, the most direct method of measuring this angle is to compare the sum of the squares of these lengths with the square of the distance between the two scale-pan centers. It was inconvenient to measure directly the lengths of the beams, and a temporary weighing arm was fixed to the upper part of the balance for the purpose. This was set in turn parallel to the lift and drag beams and a weight of 1 lb. moved through an accurately measured length. The moment thus caused was measured on the beams and the distance of each scale pan from the point of support of the balance deduced. The method of calculating the angle, referred to above, can now be applied. The angle between the beams in each of the N. P. L. balances is 90 deg. with an error not exceeding 0.02 deg. The error in the drag measurement will not exceed ½ per cent due to this cause, and will usually be much less.

Determination of Wind Direction

The accuracy with which it is necessary to set the beams along and across the wind direction is the same as that with which the angle between the beams is required to be a right angle. An error in the two cases has the same result—to include a component of the lift in the drag measurement.

The wind direction has been found to be parallel to the walls of the tunnel to an accuracy of 0.1 deg., but it is determined by the experiment which gives the angle between it and the drag beam.

The method which has been used for this determination is to mount an aerofoil in the balance, with its span vertical, and measure the lift and drag over the usual range of angle. The model is then rotated through 180 deg. about the wind direction (thus reversing the direction of the lift) and a second set of measurements taken. The mean of the two sets gives the true value of the faces, and their difference enables the errors of wind direction and balance setting to be determined.

Calibration of Tunnels

An actual set of observations which was obtained in calibrating of the tunnels showed that the two lift curves differed by an angle of 0.2 deg., the datum line to which the aerofoil was set being half this amount in error from the true wind direction. The drag curves, however, could not be made to agree by movement of one of them along the abscissas; the difference being due to the drag beam not being set along the wind direction. As would be expected, since the difference in the drag curves was due to a component of the lift, the two drag curves crossed at the angle of zero lift. The angle error can be estimated by moving one curve along the angle base by the amount indicated by the lift curves (0.2 deg.) and reading off the drag from each curve at several angles. If L is the lift at any angle and α the angle between the beam and the wind direction, then half the difference is equal to $L \sin \alpha$, and α can be deduced. In this case α was equal to 0.16 deg. The balance was turned through this angle by adjusting the length of the "torque stop," and the experiments repeated, using the wind direction indicated by the lift curves. The forces should now be in agreement for the two presentations of the model.

*See Rpt. Adv. Comm. for Aero., 1912-13, p. 50, *et seq.*

‡Rpt. Adv. Comm. for Aero., 1912-13, p. 63.

A pitot and static pressure tube of the type used by Dr. Stanton was adopted for measurement of wind velocity. The head in use at the present time is the same in principle, but has been arranged somewhat differently for convenience. This type of head has been tested on the whirling arm at the Laboratory,* and the difference of pressure was found to be $\frac{1}{2}\zeta V^2$, while that in the static pressure tube was equal to the pressure of the undisturbed air in the building. The accuracy was limited by that of the test, which was of the order of 0.1 per cent on the velocity.

It was at first hoped to measure the velocity in the tunnel during a test by mounting this head some 3 ft. (100 diameters of the vertical tube of the head) upstream of the model. This plan was abandoned, as it was found that there was a region in the neighborhood of the balance about 1½ in. wide in which the velocity was 10 per cent below the mean. The alternative method which was adopted consisted in measuring the pressure difference between a hole in the side of the tunnel and the free air in the room. In order that the pressure in this hole may not be changed by the presence of the model, it should be located sufficiently far upwind of the balance to be in front of the model. The pressure difference is greater than $\frac{1}{2}\zeta V^2$, on account of the pressure drop in passing the honeycomb and early part of the tunnel. The pressure difference, however, varies as V^2 and the tunnel is readily calibrated by placing the standard anemometer over the balance. This calibration can be made with an accuracy of about 1 per cent on V^2, and should be repeated at stated intervals. The pressure difference is measured on a Mattock tilting manometer, which has been fully described elsewhere.†

Types of Manometers

The Mattock manometer is in general use at the N. P. L., but it suffers from one defect which is not present with the inclined tube type of gage. It is necessary that the Mattock manometer shall have continuous attention during the time it is in use, and in the case of a failure of the electric supply the observer can seldom shut the tap before the surface is ruptured. It is then usually several minutes before the gage can be used again, and it is liable to change of zero for a longer period.

Experiments have been carried out at Massachusetts Institute of Technology with the "Krell" type of inclined tube manometer,‡ and the conclusion arrived at was that if properly constructed and used the gage could be regarded as an instrument of precision suitable for wind tunnel work. It requires calibration, and may be compared with a Mattock manometer which is an absolute standard. The inclined tube gage appears to be sufficiently accurate for use on a tunnel where the fluctuations usually limit the accuracy attainable. It cannot be too strongly stated that a steady electrical supply is a matter of the highest importance if accurate results are required. In the author's opinion there is no doubt whatever that, with tunnels of the type in use at the N. P. L. and with the usual conditions of electrical supply, the accuracy of the observations depends entirely on the steadiness of the wind speed. If a tunnel which normally works on the ordinary supply circuits is connected to a storage battery, the improvement in the accuracy of the experiments and the reduction in the time taken is most marked. If a storage battery cannot be provided, a Tirrell regulator makes a fairly efficient substitute. The author has had no experience with automatic speed regulators; the only one of which he has seen a description (in use on the tunnel at Göttingen) is operated by the pressure difference on either side of the fan. In order to avoid "hunting," it appears that it would be preferable to adopt a device (possibly operated by centrifugal force) which would regulate directly on the speed of the fan, since the variations here are presumably the source of speed variations in the tunnel.

Comparison of the Tunnels

The differences between the 3-ft., 4-ft. No. 1 and 4-ft. No. 2 tunnels are small, and confined to improvements in the convenience of working in favor of the latter. The woodwork of the two 4-ft. tunnels is the same, and though no comparative measurements of steadiness have been made, there appears to be little to choose between the two. The maximum speed of the 4-ft. No. 2 is 80 ft. per sec., while that of the 4-ft. No. 1 is 50 ft. per sec.

The 7-ft. No. 2 tunnel is not an exact copy of the No. 1. The buildings in which they are housed are of approximately the same size, but as the newer tunnel is supported on steel frames instead of concrete columns, the obstruction to the flow of air returning to the intake of the tunnel is appreciably less.

The overall dimension is 86 ft. in each case, but the two tunnels differ in the manner shown in the following table of approximate values:

Comparison of Wind Tunnels at National Physical Laboratory

	No. 1, 7 Ft.	No. 2, 7 Ft.	No. 1, 4 Ft.	No. 2, 4 Ft.
Overall length	......	......	52 ft.	52 ft.
Length of parallel portion	41 ft.	41 ft.	25 ft.	25 ft.
Intake to balance	20 ft.	25 ft.	6 ft.	6 ft.
Length of distributor	35 ft.	32 ft.	21½ ft.	4 ft.
Length of core to propeller	10 ft.	13½ ft.	4 ft.	21½ ft.
Angle of cone (internal)	20 deg.	20 deg.	30 deg.	30 deg.
Diameter of propeller	10 ft.	11½ ft.	5½ ft.	5½ ft.
Effective pitch diameter§	0.50	0.7	0.60	0.75
R.p.m. at 60 ft. per sec	1000	910	(50 ft. per sec.) 1350	1300
Power absorbed at 62 ft. per sec	48 hp.	56 hp.	(50 ft. per sec.) 8 hp.	14.6 hp.
R.p.m. at 80 ft. per sec	......	1210	......	1500
Power absorbed at 80 ft. per sec.	......	155 hp.	......	(70 ft. per sec.) 23.3 hp.

§Effective pitch is calculated from air speed in the tunnel just before the propeller (neglecting increase of velocity due to inflow) divided by revs. per min.

The 7-ft. No. 2 tunnel has been found to be less steady than the 7-ft. No. 1, in spite of the increased area available for the returning air. The difference is possibly due to the increase in the pitch of the propeller, and possibly also to the reduced length of the distributor.

A few particulars of the cost of erecting the wind tunnels may be of interest. The figures given were estimated to cover replacement under present conditions in the event of loss by fire, and are based on the actual cost of erection under the supervision of H. M. Office of Works:

Costs of Wind Tunnels

	No. 2, 7 Ft.	No. 2, 4 Ft.
Total	£2,120 ($10,320)	£590 ($2,870)
The more important items are:—		
Engine	300 (1,460)	60 (292)
Honeycombs (2)	75 (365)	35 (170)
Balance	350 (1,700)	250 (1,230)
Woodwork	1,000 (4,867)	80 (390)
Fan	35 (170)	50 (243)

*"Engineering," Sept. 12, 1913.

†Rpt. Adv. Comm. for Aero., 1912-13, p. 35.

‡Smithsonian Misc. Co., Vol. 62, No. 4, p. 34.

We may now pass to the consideration of the methods which are used for supporting models in the tunnel.

Methods of Support

There is perhaps no more difficult part of an investigation into the wind forces acting on a model than that which is concerned with the increase of resistance due to the supports. The difficulty depends to a large extent on the kind of model which is under test. If the resistance of a sphere, or a square plate in normal presentation, was being investigated, it is unlikely that any appreciable error would be introduced by the assumption that the correction to be applied is given by a measurement of the resistance of the supports in the absence of the model. In the measurement of the resistance of a "stream-line" body, however, an entirely different state of affairs exists. The resistance of an airship model 6 ft. long and 0.5 ft. in diameter is in some cases only about 1/100th of that of a square plate whose area is equal to that of the maximum cross-section of the airship model. Even though such a model is supported on a spindle about 0.3 in. diameter, an error amounting in some cases to as much as 20 per cent of the model resistance would be introduced if this method of measuring spindle resistance were adopted. In the test of some models several alternative methods of test are available. Thus in experiments on aerofoils the method which is usually adopted is to mount the model, with its span vertical, on a spindle screwed into its end.* An alternative method (which was adopted by Eiffel) is to support the model with its span horizontal on a spindle screwed into, for instance, its under surface, the spindle being constructed in such a manner that the angle of incidence of the aerofoil can be varied. In this case the support can be made of "fan" form, while in the former one it turns with the model, and is therefore circular. If a low-resistance aerofoil whose span is 18 in. and chord 3 in. is under test, the relative values of the spindle resistance in the two cases of span vertical and the span horizontal are about 60 per cent and 110 per cent of the minimum drag. These high values are caused by the length of spindle which must be exposed in order that the presence of the guard may not interfere with the flow round the model. It is therefore seen that the resistance of the spindle is nearly doubled when the span of the model is horizontal, and though this is bad enough it does not constitute the most serious objection to the method. The methods of evaluating the resistance of spindles have recently received a good deal of attention, and it has been shown that while, in the case of the spindle in the end of the model, the increase in resistance is not very different from that of the resistance of the actual spindle, there is much "interference" between the model and the spindle when the latter is attached to the under surface of the aerofoil.

It is therefore desirable, whenever possible, to test aerofoils with spindles in their ends; in cases (such as experiments on wing tips) where this cannot be done, great care must be taken in the determination of the resistance due to the support.

Stability

The question of stability of aircraft has been examined mathematically in considerable detail, the methods of developing the equations being laid down in Bryan's "Stability in Aviation." These methods have been developed by Bairstow, with the assistance of various members of the aeronautical staff of the laboratory. In Report 77* the theories have been applied to the flight of an airplane, and were investigated for the case of an airship in 1916.

*Rept. Adv. Comm. for Aero., 1912-13, p. 77

It is proposed to examine the methods which have been employed in measuring in the wind tunnel the various forces, moments, and damping coefficients for models of actual machines. For the purpose of stability calculation the axes are supposed to be fixed in the machine, and the nomenclature which has been adopted at the laboratory is as follows:

Mathematical Nomenclature Adopted by the National Physical Laboratory

Name of Axis	Symbol	Name of Force	Symbol	Name of Angle	Symbol	Name of Moment	Symbol
Longitudinal	X	Longitudinal	X	Roll	ζ	Rolling	L
Lateral	Y	Lateral	Y	Pitch		Pitching	M
Normal	Z	Normal	Z	Yaw	ψ	Yawing	N

If the center of gravity is at *o*, the positive directions of the axes are as follows when the machine is in rectilinear flight in a horizontal plane:—*ox* in the direction opposite to that of flight, *oy* to the left (that is, to port), and *oz* vertically upward. Forces are positive when acting along the positive directions of the axes, angles and moments are positive when turning occurs, or tends to occur, from *ox* to *oy*, *oy* to *oz*, or *oz* to *ox*. Angular velocities about the axes *ox*, *oy*, *oz* are represented by p, q, r, and linear velocities along them x, y, and z.

The rate of change of one quantity with regard to another of which it is a function is represented, in the usual manner, by writing the symbol for the latter as a suffix to that for the former. Thus the change of pitching moment due to pitching is represented on the system of axes chosen by Mq. The author's experience has shown it to be desirable, if mistakes are to be avoided, that a system of axes, such as the one quoted, should be adopted for all wind-tunnel work, and rigidly adhered to. The angle scale on the balance should be numbered in such a manner that rotation from X to Y increases the reading; the micrometer screw of the main moments apparatus should be graduated so that a moment which tends to turn the model from X to Y gives a reading greater than the zero. If the angle of pitch of a model is to be changed by rotation about a vertical axis, it should be mounted if possible with its under surface facing along the axis of Y. Forces, angles, and moments will now have their correct signs, except for normal force, for which the sign must be reversed. Care must be taken to correct the signs if the model is mounted in the reverse way, as is usually done in determining yawing moments on an unsymmetrical model.

We may now consider the determination of the quantities which must be known in order that the criteria of stability of a machine may be calculated. The first operation will be to mount the model in the tunnel in the usual way and determine the equilibrium forces on it. These results enable us to calculate (on the assumption that the wind forces vary as the square of the velocity) the resistance derivatives for variation of wind speed.

The derivatives for variations of velocity along the axes Y and Z are given by the curves of normal and lateral force for angles of pitch and yaw. If the angle base is degrees, the value of Zw/U or Yv/U is obtained by multiplying the slope of the curve near the origin by

*Rept. Adv. Comm. for Aero., 1912-13, p. 135.

57.3 to convert degrees to radians and dividing by the square of the wind speed.

It remains to measure the resistance coefficients due to oscillations through the equilibrium position, which have been called rotary derivatives.

The experimental determination of these quantities has already been described* in connection with tests on an airplane model, and though the apparatus has been modified, the same methods are in use at the present time.

Measurements were made by the method of observing oscillations, and only five of the more important derivatives were considered. These were:

The Pitching moment due to Pitching—Mq
The Rolling moment due to Rolling—Nr
The Yawing moment due to Yawing—Lp
The Rolling moment due to Yawing—Np
The Yawing moment due to Rolling—Lp

The first three can be determined by observations of the damping of a natural oscillation, but the last two require that the model shall be oscillated about one axis while it is free to oscillate about another at right angles to it. The method was to set up an oscillation about the axis of yaw (or roll) and to adjust the period about the axis of roll (or yaw) till resonance was obtained. The motion about the first axis was then stopped and the decay of the motion about the second axis observed. The determination of these derivatives by forced oscillations was found, however, to be a matter of some difficulty, and the results can only be regarded as preliminary.

The remaining three derivatives, Lp, Mq, and Nr, were determined in the wind tunnel by observation of the damping of natural oscillations. The method for Mq and Nr was to mount the model on the balance in the same manner as for an experiment on the forces, the balance being free to rotate about a vertical axis. The motion was controlled by springs which maintained the oscillations for a period of from 20 to 40 seconds against the damping due to the wind forces and the friction of the apparatus. The damping of the oscillations were recorded photographically for several wind speeds. Reduction of the results consists in plotting the logarithm of the double amplitude on a "number of swings" base for each wind speed (including zero). These lines are approximately straight for the part of the curve over which the amplitude is reduced from its maximum value to half, and the logarithmic decrement is consequently determined from this slope. If the slope at zero wind velocity is subtracted from the slope at each of the other velocities and the result divided by the periodic time (T) at that wind speed we get values of $\frac{h_1}{2I}$ where h_1 is the damping due to the wind and I the moment of inertia. If each value is divided by the appropriate wind speed (U), we find the damping to be nearly proportional to the speed. I can be calculated from the equation

$$T = \frac{2\pi}{\sqrt{\frac{k_1}{I} - \frac{h_0^2}{4I^2}}}$$

where T is the periodic time at zero wind velocity, k_1 the moment due to the apparatus, and h_0 the damping due to friction. We can now obtain values of $\frac{h_1}{U}$, and if we neglect change of the coefficients with scale and speed we can calculate $\frac{BMq}{U}$ and $\frac{CNr}{U}$ by multiplying by the fourth power of the ratio of the dimensions of the actual airplane to those of the model, B and C being the moments of inertia in pitch and yaw respectively.

*Rpt. Adv. Comm. for Aero., 1912-13, p. 172.

Scale and Speed Effect

In considering the application of model results there is one important correction which it is necessary to apply to the great majority of experiments in a wind tunnel; it is that for change of size and speed between the model and the actual machine. It has now been well established that for what may be called totally submerged bodies, such as aircraft or torpedoes, where the type of motion is determined by the viscosity of the fluid, we may write

$$F = \zeta v^2 l^2 f\left(\frac{vl}{V}\right)$$

where F is the resistance to forward motion, v the velocity, l a dimension of the body, and ζ and V the density and kinematic viscosity of the fluid. If the form of the function is unknown, we can only be sure that the motion in an experiment on a model will be similar to that on the actual machine if the value of $\left(\frac{vl}{V}\right)$ is the same in the two cases. This condition is usually unobtainable in wind tunnel tests, as both the size and the speed are much higher in practice; in the case of rigid airships the value of vl for the actual ship is some 200 times that in the model test. By carrying out tests in water v can be reduced to 1/14th that of air, but the experimental difficulties then become very great and in most cases outweigh the advantages of an increase in the value of $\left(\frac{vl}{V}\right)$

Experiments on full-scale machines are admittedly extremely difficult, and it is only recently that they have been carried out on airplanes. It is hoped that in the near future resistance experiments on full-size airships will be made.

Experiments on models over the greatest possible range of speed appear, in many cases, to indicate that the power of the velocity which the resistance varies at is not very different from 2 at the highest value of $\left(\frac{vl}{V}\right)$ obtainable.

If FaV^2, then $f\left(\frac{vl}{V}\right) = 1$, and we can calculate the forces on the actual machine directly from our model experiment.

A very large amount of data has been obtained in testing the airplanes which are being constructed for naval and military forces, and comparisons of the greatest value are now possible between the results on models and actual machines. The author believes that the time is not far distant when the design of new machines will be essentially based on the results obtained in experiments on small-scale models in a wind tunnel.

Current Standardization Work

THE letter ballot on the standards adopted at the January meeting has been received. All the recommendations were approved by the voting members of the Society and the standards, therefore, are officially adopted. The complete result of this vote is given in this issue.

Below is given the outline of the work done at recent meetings of the Aeronautic and Marine Divisions of the Standards Committee.

Aeronautic Division Meetings

TURNBUCKLES

UP to the present time there have been no generally accepted standards of turnbuckle dimensions, although specifications and drawings have been offered by various organizations. The International Aircraft Standards Board and the U. S. Signal Corps, for instance, have both published turnbuckle specifications. It was to clarify this situation that the Aeronautic Division undertook the establishment of a simplified turnbuckle series and it is believed that the underlying features of the latter rectify all existing inconsistencies in other standard designs in use, and at the same time will permit the new design to be interchangeable with designs following present accepted practice.

This entire subject was taken under consideration at a meeting of the Aeronautic Division, also attended by turnbuckle manufacturers, held at Dayton, Ohio, on March 11.

John V. Costello and Standards Manager Hanks submitted a report including proposed dimensions for turnbuckles. These dimensions will probably be published in the April issue of THE JOURNAL, but, for the benefit of those who wish to submit suggestions to the Division, the principal features of the S. A. E. turnbuckle are outlined here.

A comparison of the S. A. E. and old turnbuckles is shown in the following:

S. A. E. Turnbuckles	*Old Turnbuckles*
Standard A. S. M. E and S. A. E. threads same as airplane bolt sizes.	Non-standard threads taken from the English.
Two standard turnbuckle lengths, 4½ and 8 in. for long and short.	Formerly 20 different lengths.
Two barrel lengths, 2¼ and 4 in.	Formerly two lengths, 2 in. and 4 in., which allowed in one case for only ⅛-in. take-up.
Three hole sizes in fork end and three pin lengths.	Formerly four hole sizes and five pin lengths.
More liberal tolerance.	
More take-up on short sizes.	

In general the following specifications, which are the latest recommendation of the International Aircraft Standards Board sub-committee on turnbuckles, would apply to the S. A. E. turnbuckle.

Specifications for Turnbuckles

General—1. The general specifications, 1G1, shall form according to their applicability a part of these specifications.

Material—2. Barrels shall be made of naval brass or equivalent alloy, I. A. S. B. specifications 3N4. The shanks shall be made of steel, I. A. S. B. specifications 3S4.

Physical Properties and Tests—3. (a) At least 2 per cent of all turnbuckles shall be subjected to the test load given in the table and must withstand this test when threads are flush with the end of the barrel.

(b) Steel turnbuckle shanks shall be heat-treated to withstand the test loads specified.

(c) A bend test shall be made upon a (unbroken) shank of each turnbuckle tested in tension; the shank must withstand bending through 90 deg. without cracking.

Dimensions and Tolerances—4. Dimensions and tolerances are given in the tables following. (Will probably appear in April issue of THE JOURNAL.)

Finish—5. Turnbuckles shall be finished smooth and free from tool marks.

Assembly—6. The threads are to be greased and must have a snug, true fit allowing the barrel or shank to be turned by hand and showing absolutely no slackness in fit or perceptible end shake with three threads exposed.

Protective Coating—7. Turnbuckle shanks shall be thoroughly covered with a suitable noncorrosive grease to prevent rust.

LANDING WHEELS FOR AIRCRAFT

A MEETING of the Committee on Tires and Tubes of the Aeronautic Division was held Feb. 8 in Cleveland, at which the following report was submitted for further consideration. The specification is published here to encourage constructive criticism for the benefit of the Aeronautic Division. The meeting was attended by J. V. Costello, Mr. Darrow, Mr. McMahan, I. R. Renner, J. D. Tew, J. C. Tuttle, W. S. Wolfe, and Standards Manager M. W. Hanks.

General.—The specification, as submitted, covers the general requirements of tires and tubes for airplane landing wheels, it being the aim to confine the number of sizes to as few as possible. Larger sizes than listed below will probably be required, and the proposed specification will be extended to include these sizes as soon as demanded.

All tires and tubes shall be free from defective material and workmanship, and shall conform to the following general construction, limits and tests:

Tire Construction and Dimensions

Tires shall be of the clincher type, smooth tread, constructed of two or more cord plies of long staple cotton, so arranged that an equal number of plies run in each diagonal direction across the tire. Each ply shall be separated from the adjoining ply by rubber compound. Enough rubber compound must be put on side wall to insure ample protection of tire body. Tread stock, specific gravity 1.30 maximum. Inside of tires need not be painted.

Tire beads shall be constructed so as to insure against pinching and to properly fit the rim contours shown in accompanying drawing and table.

The dimensions and weights of the finished tires shall be according to the following table and within the limits specified:

TIRE DIMENSIONS AND WEIGHTS

	Dimensions				Weights†	
	Size		Thickness		Max.	Min.
	Tire*	Rim No.	Tread, Min.	Sidewall, Max.		
Millimeters	700x75	U_3	1.588	0.794	2.410 kg.	2.123 kg.
Inches	27.56x2.95		1/16	1/32	5 lb. 5 oz.	4 lb. 11 oz.
Millimeters	700x100	Z_2	2.381	1.191	4.137 kg.	3.851 kg.
Inches	27.56x3.94		3/32	3/64	9 lb. 2 oz.	8 lb. 8 oz.
Millimeters	750x125	Z_2	2.381	1.191	4.989 kg.	4.650 kg.
Inches	29.53x4.92		3/32	3/64	11 lb. 0 oz.	10 lb. 4 oz.
Millimeters	800x150	Z_3	3.175	1.191	6.002 kg.	5.615 kg.
Inches	31.49x5.90		1/8	3/64	13 lb. 4 oz.	12 lb. 6 oz.

*Section widths and tire diameters when inflated 50 lb. per sq. in. shall not vary more than 4 per cent over or more than 2 per cent under nominal specified tire sizes.
†Weight without flap.

Marking.—Each tire shall be branded with the manufacturer's name, size, serial number, and rim number the tire is intended to fit.

Tubes.—Tubes shall be constructed of rubber compound to dimensions, weights and tolerance given in table, and shall withstand physical tests specified.

TUBE DIMENSIONS AND WEIGHTS

	Tire Size	Mandrel Diam., Min.	Wall Thickness, Min.	Weight* Approx.	Specific Gravity, Max.
Millimeters	700x75	47.63	1.194	0.4536 kg.	1.25
Inches	27.56x2.95	1 7/8	0.047	1 lb. 0 oz.	1.25
Millimeters	700x100	60.33	1.372	0.6804 kg.	1.25
Inches	27.56x3.94	2 3/8	0.054	1 lb. 8 oz.	1.25
Millimeters	750x125	76.20	1.575	0.9355 kg.	1.25
Inches	29.53x4.92	3	0.062	2 lb. 1 oz.	1.25
Millimeters	800x150	82.550	1.575	1.1911 kg.	1.25
Inches	31.49x5.90	3 1/4	0.062	2 lb. 10 oz.	1.25

*It is suggested that the maximum and minimum weights be specified for tubes as well as for the tires.

Tube Tests.—Tubes must withstand the water test mentioned under tire test, and shall have the following physical properties when subjected to the Bureau of Standards' test No. 33R-3-B, dated June 1, 1916:

Physical Test of Tubes

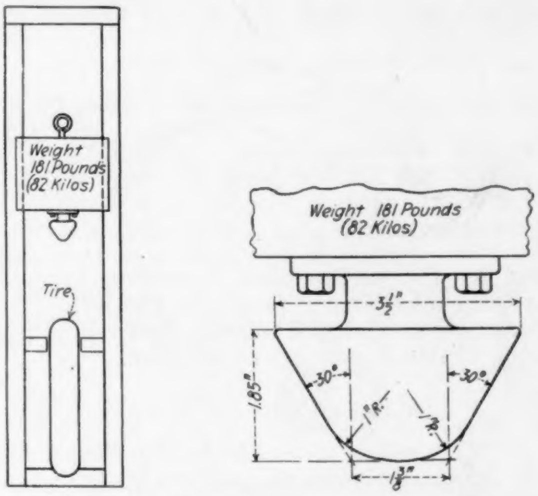
Minimum tensile strength .... 1500 lb.
Minimum stretch .... 600 per cent
Maximum set (2 minutes after rupture) ... 25 per cent

Valve.—The valve to be used will be of the bent type with adapter for American and foreign pumps.

Tire and Tube Tests Combined

The manufacturer shall make a sufficient number of tests on the tires and tubes coming through production to satisfy himself that the product is up to the requirements of this specification.

Impact Test.—The tire is mounted with the tube on a special rim of standard contour that will withstand the pressures given in the table. The tube is inflated with

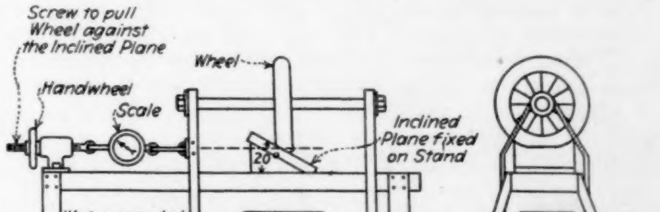


PROPOSED IMPACT TEST FOR PNEUMATIC TIRES
General Arrangement of Apparatus shown on Left. Detail of Contact Head shown on Right

air and maintained at a pressure of 150 lb. per sq. in. In this condition the tire must withstand a blow delivered on the tread by a weight of 181 lb (82 kg.), having a contact surface as indicated in the diagram, and falling through the distances indicated in the following table:

Size in Mm.	Drop	
	In Inches	In Mm.
700x 75	45	1143
700x100	55	1397
750x125	55	1397
800x150	55	1397

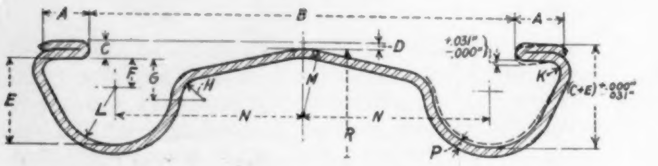
Side-Thrust Test.—All airplane tires, from 700 x 75 to 800 x 150 mm. inclusive, when mounted on standard rims, inflated to 50 lb. air pressure, and loaded with a dead weight of 2000 lb., shall withstand 1800 lb. lateral stress against a plane of 20 deg. with the horizontal, as shown in the illustration, without pulling off the rim.



PROPOSED AIRPLANE LANDING WHEEL SIDE-THRUST TEST
The Center Line of the Screw (Line of Pull) Should Come at the Point of Contact of the Tire with the Inclined Plane

Water-Pressure Test.—All airplane tires from 700 x 75 to 800 x 150 mm. inclusive, when mounted on special rim standard contour, shall withstand a water test of 200 lb., pressure not to be raised at a rate exceeding 50 lb. per minute.

Landing-Wheel Rims.—The accompanying table shows the landing-wheel rim dimensions proposed by the committee. Additional inspection requirements, besides those indicated by the table, are that the rim out-of-flat shall not exceed 1/16 in. when free on surface plate; rim tolerance for out-of-round is 3/32 in.; buckled rims are covered by the surface-plate inspection and tolerance limits; rims must be free from defective welds. The table of dimensions is published in order to obtain constructive criticism for the benefit of the Division.



Cross Section of Landing-Wheel Rim

Marine Division Meeting

A JOINT meeting of the Marine Division of the S. A. E. Standards Committee and the Executive Committee of the National Association of Engine and Boat Manufacturers was held in New York March 1, attended by the following members of the Marine Division: Chairman H. R. Sutphen, who acted as chairman of the joint meeting; W. S. Howard, Joseph Van Blerck. The others in attendance were H. H. Brantigan, Bridgeport Motor Co., Bridgeport, Conn.; C. F. Chapman, *Motor Boating*, New York; George J. Crouch, Motor Boat Publishing Co., New York; W. L. Fay, Fay & Bowen Engine Co., Geneva, N. Y.; Ira Hand, National Association of Engine & Boat Manufacturers, New York; G. F. Lawley, Lawley Corp., Neponset, Mass.; F. K. Lord, New York; A. E. Robinson, Regal Gasoline Engine Co., Coldwater, Mich.; A. W. Toppan, Toppan Boat Manufacturing Co., Boston; Standards Manager M. W. Hanks, and R. S. Burnett, S. A. E., New York.

Mr. Van Blerck spoke of the value that S. A. E. standards had been to his company. Formerly if he wanted to provide a space for a magneto on a new design of engine he had first to get the dimensions of the particular make of magneto he intended to use and then instruct the draftsman to provide for that size. This involved much correspondence and cost. Now he refers to the S. A. E. standard magneto dimensions and knows that any make of standard magneto will fit.

Standards Manager Hanks compared the manufacturers of motorboats and the manufacturers of automobiles, and pointed out that the manufacture of launches and small commercial boats was more of an assembly matter than the manufacture of automobiles; therefore, standardization of routine engineering details would mean a great saving to the marine industry. Engines, reverse-gears, couplings, propellers and the boats are all made in different shops and everyone follows his own particular fancy in selecting a part to "hook up" with something made in another shop. Engine-bed widths vary by quarter-inches, shaft centers are measured above or below engine foundations by eighth-inches. Three or four standard engine widths with possibly one or two heights of shaft centers above the engine foundation ought to answer all purposes and save endless correspondence and expense for both engine manufacturers and boat builders.

Tables of Airplane Landing-Wheel Rim Dimensions

In Inches

Rim Size	Tire Size		A +0.031 −0.000	B ±0.046	C +0.021 −0.006	D ±0.016	E	F	G	Radii				N	P	Diam. R	Circum.* (π R.)
	Mm.	Inch								H	K	L	M				
U_3	700x75	27.56x2.95	13/64	1 39/64	0.104	0.049	27/64	13/64	0.159	1/8	0.039	7/32	19/64	45/64	0.052	21 25/64	67.201
U_5	575x60 600x75	22.60x2.36 23.62x2.95	13/64	1 39/64	0.104	0.049	27/64	13/64	0.159	1/8	0.039	7/32	19/64	45/64	0.052	18 1/64	56.598
Z_2	700x100 750x125	27.56x3.94 29.53x4.92	5/16	2 11/16	0.104	0.042	9/16	3/16	0.266	3/16	5/64	3/8	1/2	1 3/16	0.052	20 5/32	63.323
Z_3	800x150	31.50x5.91	5/16	2 11/16	0.144	0.082	9/16	3/16	0.266	3/16	5/64	3/8	1/2	1 3/16	0.072	20 5/32	63.323

*Tolerance from Nominal after Lacing +0.000 to −5/64 in.

In Millimeters

Rim Size	Tire Size	A +0.787 −0.000	B ±1.168	C +0.533 −0.152	D ±0.406	E	F	G	Radii				N	P	Diam. R	Circum.* (π R)
									H	K	L	M				
U_3	700x75	5.156	40.868	2.642	1.245	10.719	5.156	4.039	3.175	0.991	5.563	7.544	17.856	1.321	543.330	1706.903
U_5	575x60 600x75	5.156	40.868	2.642	1.245	10.719	5.156	4.039	3.175	0.991	5.563	7.544	17.856	1.321	457.606	1437.587
Z_2	700x100 750x125	7.950	68.273	2.642	1.067	14.300	4.775	6.756	4.775	1.981	9.525	12.700	30.174	1.321	511.962	1603.402
Z_3	800x150	7.950	68.273	3.658	2.083	14.300	4.775	6.756	4.775	1.981	9.525	12.700	30.174	1.829	511.962	1603.402

*Tolerance from Nominal after Lacing +0.000 to −1.981 mm.

Mr. Lawley said it would help greatly if engine beds could be furnished in definite sizes, but thought there might be considerable difficulty in unifying the great variation in design of engines now on the market.

It was proposed to send a blank form to engine and reverse-gear manufacturers to obtain the essential dimensions of their products.

Shaft Couplings and Propeller Mounts

Mr. Howard reviewed the work of the committee on this subject and asked for the cooperation of all those interested in the manufacture of associated parts.

There was considerable discussion as to the best expression for designating shaft tapers. Shaft couplings, for instance, have a taper of 1½ in. per ft. specified. If the lathe taper was set at a taper of 1½ in. per ft., the included angle of the resulting taper would be 3 in. per foot. The expression "1½ in. per foot included angle" is definite. An error in the large size propeller mount taper was noted. It read "3 in. per foot." It should read "¾ in. per foot included angle."

Standardized Units for Lifeboats

Chairman Sutphen spoke of the lifeboat problem for both merchant and cargo ships. More power lifeboats are needed, as they assist materially in keeping the oar-propelled lifeboats from getting separated and lost, and give invaluable assistance in getting the boats to port.

Both steel and wooden power lifeboats are being discussed in marine circles. Chairman Sutphen will appoint a general committee to investigate the possibilities of standardizing the detail units for lifeboats. There is also to be a sub-committee on Lifeboat Power.

Cooperation with Boat Builders

Now that the objects and benefits of the marine standards are becoming better known, it was suggested that an effort be made to have as many joint meetings as possible with the National Association of Engine and Boat Manufacturers' Executive Committee.

The following committee was recently appointed from the National Association of Engine and Boat Manufacturers to work in conjunction with the Marine Division of the Standards Committee in developing the unit parts for a standardized motor lifeboat: Henry R. Sutphen, chairman; George F. Lawley, Capt. A. P. Lundin, James Craig, and Charles A. Criqui.

Chairman Sutphen has appointed a Committee on Boat Fittings composed of Charles D. Durkee, chairman; Arthur W. Toppan, and John Tiebout, and a Committee on Engine Beds composed of Joseph C. W. Van Blerck, chairman; George F. Lawley, and Walter L. Fay.

REGULATIONS GOVERNING WORK OF STANDARDS COMMITTEE

At the Feb. 25 meeting of the Council the following revised form of the regulations governing the activities of the Standards Committee was adopted. It was recommended that the work of the Standards Committee proceed along the same lines as have been followed during the past year until need for change arises, at which time the Chairman of the Standards Committee will submit further report.

I—Origin and Functions

1—The Standards Committee of the Society of Automotive Engineers, under the discretion of the Council, shall have jurisdiction over the formulation of all standards and recommended practices which may come before the Society for final adoption. It may also be charged with such special deliberations or investigations as the Council may deem advisable or necessary for the preparation of authoritative reports. The results of these investigations may, in the discretion of the Council, be made the subject of special reports.

II—Organization

2—The Standards Committee shall act under the direction of a Chairman, who shall be, ex-officio, a member of each Division, and shall be assisted by a Standards Manager.

3—The whole committee shall be resolved by the Council into a number of Divisions, each charged with the consideration of an appropriate group of subjects, and presided over by a Division chairman. Any Division may be resolved further into such Subdivisions as the Division chairman may deem expedient.

III—Appointments

4—Appointments to membership on the Standards Committee shall be made annually by the Council in conference with the Chairman of the Standards Committee. Interim appointments may be made by the Council. The Chairman of the Committee and of its Divisions shall be designated annually by the President of the Society.

5—The President and the Secretary of the Society shall be, ex-officio, members of the Standards Committee and of its Divisions.

IV—Procedure

In Divisions

6—However initiated, proposed new standards or revision of existing standards must issue as a report from that particular Division within whose province such matters properly belong. This report may, at the discretion of the Chairman of the Standards Committee, be submitted to letter ballot of all the members of the Division from which it issues. A majority of the members of a Division shall constitute a quorum. A majority

of those voting shall be necessary to approve a report. Dissenting members shall have the right to present minority reports individually or jointly.

7—No action affecting the substance of reports shall be taken by any Division except at meetings called for that purpose or by letter ballot of the Division.

8—Reports should consist generally of complete but concise statements of the practices and constructions, as recommended, together with such illustrations as may be necessary. There should be appended also explanatory remarks of the recommendations made.

In Standards Committee

9—Reports of the Divisions shall be submitted to the Standards Committee for approval at regular or special sessions or, in the discretion of the Chairman of the Standards Committee, shall be submitted by letter ballot to all the members of the Standards Committee if necessary for prompt action. Fifteen members of the Standards Committee shall constitute a quorum. After approval by the Standards Committee, in original or amended form, Division reports shall be transmitted, with a statement of the action thereon, to the Council for its approval for submission to the Society. The majority of those voting in the Standards Committee shall be necessary to approve a report.

In Council and Society

10—After approval by the Council, each Division report approved by the Standards Committee shall be submitted for discussion to the Society at a properly constituted annual or semi-annual meeting, at which it may be amended, sent back to the respective Division, or approved for submission by the Secretary to letter ballot of the Society. A majority of those voting shall be necessary to submit to letter ballot.

The Letter Ballot

11—The letter ballot shall provide for the recording of affirmative and negative votes and waivers, and shall be returnable to the Secretary of the Society within sixty days following the meeting. The adoption of the report shall be decided by a majority of the letter ballots cast.

V—Meetings

Committee Meetings

12—Meetings of the Standards Committee shall be held on the first day of or on the day preceding each Annual and Semi-Annual meeting of the Society. The Committee shall also hold an annual convention on the first Thursday in May.

Division Meetings

13—Meetings of the Divisions shall, with the approval of the office of the Standards Committee and the Secretary of the Society, be held at any appropriate time upon ten days' notice, at the suggestion of the respective Division Chairman, or by direction of the office of the Standards Committee.

Schedules

14—When the Chairman of a Division desires to call a meeting he shall notify the office of the Standards Committee, stating the purpose, and his preference as to time and place.

VI—Committee Records

Attendance

15—The Standards Manager of the Society shall keep a roll of the members of all the Divisions and shall record the minutes and the names of all members in attendance at the meeting. In his absence such records shall be made by a representative of the Standards Manager or by the Division Chairman.

Depository for Records

16—The Chairman of any Division, or some officer of the same, after completion of each subject referred to said Division, shall transmit all correspondence filed on that subject to the office of the Standards Committee.

VII—Miscellaneous

Publicity

17—Divisions shall have no right to issue matter for publication through other than the regular Society channels, unless so authorized, for reasons of weight by the Council.

Stationery

18—Official correspondence, especially requests for information as to practice, should be conducted on official stationery, which will be furnished by the Secretary of the Society.

Expenditures

19—No obligation for expenditures other than postage will be assumed by the Society unless such expenditures shall have been incurred in pursuance of previous authorization by the Council, and then only within specific fixed amounts.

STANDARDS COMMITTEE FOR 1918

AT the Feb. 25 meeting of the Council it was recommended that the following Divisions of the Standards Committee be continued, the personnel of these to be as indicated below.

MEMBERS OF THE 1918 COMMITTEE

B. B. Bachman, *Chairman.*

Roller Chain Division

L. M. Wainwright, *Chairman*

Warren J. Belcher
John R. Cautley
Wm. F. Cole
D. P. Davies
Herbert F. Funke
W. S. Harley
H. S. Pierce
Arthur J. Scaife

Aeronautic Division

C. M. Manly, *Chairman*

Roger Chauveau
V. E. Clark
H. M. Crane
C. H. Day
F. S. Duesenberg
E. J. Hall
Spencer Heath
C. B. King
G. C. Loening
F. L. Morse
H. E. Morton
J. G. Vincent
C. F. Willard
E. H. Ehrman
B. D. Gray
G. L. Norris

Data Sheet Division

P. M. Heldt, *Chairman*

J. J. Aull
A. C. Bergmann
Edgar T. Buckingham

ELECTRIC VEHICLE DIVISION

Bruce Ford, *Chairman*

H. S. Baldwin
E. P. Chalfant
J. H. Hertner
Wm. P. Kennedy
F. E. Queeney
E. J. Ross, Jr.
A. J. Slade
E. R. Whitney
J. G. Carroll

ELECTRICAL EQUIPMENT DIVISION

A. L. Riker, *Chairman*

W. A. Frederick
Joseph Bijur
O. F. Conklin
W. A. Chryst
C. F. Gilchrist
T. L. Lee
B. M. Leece
A. D. T. Libby
H. E. Rice
A. H. Timmerman
C. E. Wilson

ENGINE DIVISION

W. A. Frederick, *Chairman*

R. J. Broege
E. G. Gunn
C. C. Hinkley
H. L. Horning
A. F. Milbrath
H. C. Snow

FOREIGN COOPERATION DIVISION

A. L. Clayden, *Chairman*

W. H. Allen
C. C. Carlton
J. E. Hale
B. Maraini
H. W. Waite

FUEL AND LUBRICATION DIVISION

H. L. Horning, *Chairman*

H. G. Chatain
C. W. Stratford

IRON AND STEEL DIVISION

K. W. Zimmerschied, *Chairman*

R. R. Abbott
W. B. Hurley
F. E. McCleary
G. L. Norris
J. H. Parker
H. J. Stagg, Jr.
H. G. Stoddard

MARINE DIVISION

H. R. Sutphen, *Chairman*

F. S. Duesenberg
W. S. Howard
E. T. Larkin
A. F. Milbrath
E. A. Riotte
Henry A. Tuttle
Joseph Van Blerck

MISCELLANEOUS DIVISION

E. H. Ehrman, *Chairman*

Clarence Carson
J. E. Diamond
C. S. Crawford
W. C. Keys
W. H. Knowles
Berne Nadall
E. E. Sweet

LIGHTING DIVISION

M. W. Hanks, *Chairman*

Paul F. Bauder
Wm. T. Jones

MOTORCYCLE DIVISION

W. S. Harley, *Chairman*

C. O. Hedstrom
C. B. O'Hare
R. F. Rogers
F. W. Schwinn
Geo. W. Dunham

TIRE AND RIM DIVISION

C. B. Whittelsey, *Chairman*

W. H. Allen
E. K. Baker
C. C. Carlton
J. E. Hale
E. O. Heinsohn
E. G. Hulse
C. B. Williams
John Kelsey
Otto Jobski

TRACTOR DIVISION

Dent Parrett, *Chairman*

H. L. Horning
C. M. Eason
D. P. Davies
T. B. Funk
E. R. Greer
R. O. Hendrickson
Raymond Olney
H. C. Buffington

TRANSMISSION DIVISION

A. W. Copland, *Chairman*

A. T. Brown
A. C. Bryan
L. C. Fuller
H. J. Garceau
A. A. Gloetzner
J. E. Gramlich
E. W. Miller

TRUCK DIVISION

H. D. Church, *Chairman*

B. B. Bachman
P. J. F. Batenburg
Wm. M. Britton
L. P. Kalb
W. T. Norton, Jr.
A. L. Riker
A. J. Scaife
Geo. W. Smith
W. R. Strickland
F. A. Whitten
John Younger
E. R. Whitney

It was recommended that the Ball and Roller Bearings Division, the Nomenclature Division and the Springs Division be continued with the understanding that the personnel for these divisions is to be named at the next meeting of the Council.

It was further recommended that the Research Division and the Starting Battery Division be discontinued.

A BIT OF FINANCIAL HISTORY

THE credit of the United States was so high and unquestionable that in 1900, two years after the Spanish War, 2 per cent bonds were offered at par and oversubscribed. This is a financial performance no other nation has ever equaled.

United States 4 per cent bonds in 1888 sold as high as 30 and in 1901 brought 139⅞ on the stock market.

The United States has never defaulted on any of its bonds. Not one of its bondholders has ever lost a cent of principal or interest except those who voluntarily have taken losses by selling their bonds in a period of temporary price depression. One hundred cents on the dollar, principal and interest, has the United States always paid.

Back of the $250,000,000,000 to $300,000,000,000 of our national resources stands the rugged honesty of America. Liberty Loan Bonds are the safest security in the world. Read the Liberty Loan announcement on page 3 of the Advertising Section.

STANDARDS ADOPTED BY LETTER BALLOT

THE recommendations as to new and revised standards* approved at the last Annual Meeting of the Society were adopted in their entirety by the letter ballot of the voting members, which closed on the 11th of March.

The total number of votes cast was 148, two of which were void because unsigned. The vote on the recommendations is given below.

REPORT OF AERONAUTIC DIVISION

	Yes	No
Dopes, cellulose acetate	36	1
Dopes, cellulose nitrate	35	2
Spar varnish	38	1
Round high-strength steel wire	63	1
Non-flexible 19 steel-wire cable	63	0
Flexible 6 x 7 steel-wire cable	63	0
Flexible 7 x 7 steel-wire cable	63	0
Extra flexible 7 x 19 steel-wire cable	63	0
Reels for aircraft cable	58	0
Tachometer drive	66	2
Rubber hose for gasoline—Type No. 1	69	1
Rubber hose for gasoline—Type No. 2	20	1
Plain hexagon nuts	82	1
Ball hexagon and castle nuts	79	2
Castle hexagon nuts	81	1
Ball hexagon-head bolts	80	2
Plain hexagon-head bolts	81	1
Clamps and fittings for rubber hose†	86	1
Airplane engine testing	65	3
Airplane engine testing form	71	2
Engine weight specifications	76	2
Spark-plug shell dimensions	80	1
Bevel washers	89	1

REPORT OF DATA SHEET DIVISION

	Yes	No
Canceled data sheets	101	2
Changes in nomenclature	103	0

REPORT OF LIGHTING DIVISION

	Yes	No
Head-lamp illumination	106	0
Head-lamp bulbs	101	1

REPORT OF MARINE DIVISION

	Yes	No
Flange Steel Coupling—Engine and reverse gear	63	1
Flange Steel Coupling—Reverse gear and propeller-shaft	64	1
Clamp Couplings—Propeller-shaft extension	62	1
Flange Cast-Iron Coupling — Reverse gear and propeller-shaft	59	2
Propeller mounting	56	1

REPORT OF MISCELLANEOUS DIVISION

	Yes	No
Screw threads	101	2
Bumpers and mountings	87	2
Adjustable yoke rod-ends	102	0
Plain yoke rod-ends	102	0
Eye rod-ends	102	0
Rod-end pins	101	1

REPORT OF MOTORCYCLE DIVISION

	Yes	No
Spark control	50	1
Throttle control	49	0
Kick starters	46	0
Clutch pedals	46	0
Brake pedals	47	1
Driving chains	48	0
Oil and grease cups	49	0
Engine displacement	46	0
Gearshifts	44	0
Carrying capacity	46	1
Tires	50	0
Magneto dimensions	51	2
Head-lamp mounting lugs and supporting prongs	54	6
Fuel and lubrication pipe fittings	46	0
Spokes and nipples	47	1
Wheels and rims	50	0

REPORT OF ROLLER CHAIN DIVISION

	Yes	No
Nomenclature of component parts	89	0
Roller chain dimensions	88	0

REPORT OF TIRE AND RIM DIVISION

	Yes	No
Solid-tire demountable-rim equipment	73	0
Types and dimensions of pneumatic-tire rims	82	0
Profile sizes and types of rims	81	0
Pneumatic tires for motor trucks	79	1
Motorcycle rims	66	0

REPORT OF TRACTOR DIVISION

	Yes	No
Tractor and implement drawbar connector	29	2
Magneto mounting	84	10
S. A. E. standards for tractor service	86	0
Tractor specification	83	0

*These standards were given in full in the January JOURNAL, pages 79 to 100, inclusive.

†List of sizes shown on Data Sheet 37, Vol. I, S. A. E. Handbook, is recommended for Aeronautic Practice.

Activities of S. A. E. Sections

AT the Annual Meeting, held in New York in January, a proposal was made that the Constitution of the Society be amended so as to have the Sections Committee form one of the regular administrative committees, and to consist of five members experienced in section work. While this amendment cannot go into effect for some months yet, even if it is adopted by the membership of the Society, the Council has already appointed a special Sections Committee to act in an advisory function to the local organizations of the Society. This committee replaces the Sections Committee of last year, which was composed of the chairmen of all the sections and of several other members of the Society. The new Sections Committee consists of the following:

Councilor C. S. Crawford, chairman.
Noble C. Banks of Detroit.
R. H. Combs of Toronto.
Leonard Kebler of New York.
R. J. Nightingale of Cleveland.

The functions of this committee will be mainly of an advisory nature. It will endeavor to help the sections to secure the best results from their work and will actively encourage the formation of new sections in the centers of the automotive industry.

Several sections of the Society are working with other local engineering organizations in their cities, and the Sections Committee will endeavor to work out ways and means so that such cooperation can be made of the highest value to the Society and to the engineering profession in general. Plans are now on foot to standardize the various forms used in section work, these including the letter heads, application cards, record cards, and methods of sending out bills for dues.

Practically all of the sections have now selected nominating committees who will designate officers to be voted on some time in April. The nominating committees selected by the Metropolitan, Minneapolis, and Cleveland Sections were given in the February issue of THE JOURNAL. The Nominating Committee of the Buffalo Section is as follows: David Sowers, chairman; F. W. Davis, and Forrest Cardullo; of the Detroit Section, Noble C. Banks, chairman, T. P. Chase, and Frank E. Watts; and of the Mid-West Section, Porter E. Stone, chairman, Lon Smith, F. E. Place, Francis W. Parker, Jr., and Chas. H. Roth. The Pennsylvania Section has selected Major B. D. Gray, F. M. Germane, and E. S. Fretz as its Nominating Committee. The Nominating Committee of the Indiana Section consists of O. L. Gallup, George Weidley and Chester S. Ricker.

Buffalo Section.—At the March 20 meeting of the Buffalo Engineering Society, the Buffalo Section presented a paper by W. M. Corse of Niagara Falls showing the uses in automotive construction of chilled bronzes. The next paper presented by the section will be given on April 24, when F. W. Gurney will discuss the design and manufacture of ball bearings.

Cleveland Section.—At the March meeting, held on the 15th, Mr. Tewksbury of the Cleveland Tractor Company described the general development of farm tractors. The April meeting will be devoted to a discussion of factory inspection. Johnson Heywood of the editorial staff of *Factory* will give a paper, and the inspection experts from a number of Cleveland factories will discuss it.

Detroit Section.—A meeting of this section was held March 21, at which E. W. Goodwin gave a paper on the design and construction of automobile bodies. The plans for the April meeting have not yet been settled, but several papers are under consideration, and the full details will be announced later.

Indiana Section.—Chas. A. Trask, engineer of the Rockwood Manufacturing Company, presented a paper on friction transmission as applied to tractors, at a meeting of the section held March 22.

Metropolitan Section.—The past, present and future of steam motor vehicles will be discussed at a meeting of the Metropolitan Section to be held March 28 at New York. Papers will be presented by John Sturgess of the Stanley Motor Carriage Company, and by Abner Doble of the Doble-Detroit Steam Motors Company.

Minneapolis Section.—The April meeting will be held on the third, and devoted to the methods of lubricating tractor engines. W. G. Clark will present a paper on the subject of engine lubrication, using different oils. At the meeting held March 6 two papers were presented. F. McDonough of the Toro Motor Company described a new type of hydraulic transmission designed for motor vehicles. The paper also mentioned a number of different types of devices developed for obtaining variable speeds. Mr. Scarrett's paper covered the design of gears for tractor work, and suggested that a 20-deg. stub-tooth should be standardized with definitely fixed proportions based on the pitch. Considerable information was given as to the strength and operating characteristics of the various materials available for gears.

The fundamentals of tractor engineering will be discussed at a meeting to be held May 1 in Minneapolis, when Prof. Amos F. Moyer of the experimental engineering department of the University of Minnesota will describe some research work he has been doing on the resistance to rolling of tractor wheels. A large number of rolling tests have been conducted in order to determine just how the mathematical relation involved in rolling can be applied to practical use. The experiments have been made with plain, flat-tired wheels of varying weight, width and diameter. Professor Moyer has been able to obtain a definite relation between the pull exerted on the wheel, the weight per cubic foot of wheel volume, and the so-called soil factor, which is equal to the load in pounds supported by the soil per unit volume of soil displaced. A complete account of the experimental work is to be given in the paper, which will be illustrated by a number of valuable curves showing the actual data obtained.

Mid-West Section.—It is planned to hold the March meeting of the Mid-West Section on the 22d, at the Chicago Automobile Club. Colonel Leonard D. Wildman, chief signal officer, Central Department, of the U. S. Army, will talk on the work of the Signal Corps. William Lehle, president, Commercial Motion Picture Manufacturing Company, will speak at this meeting on the subject

of moving pictures as a medium for selling automotive products.

At the February Section meeting, which took place on the 21st, E. Goldberger gave a paper on the economical size of tractors. Mr. Goldberger favors the use of a four-plow machine for farming work, stating that it is the most economical, and that even for large farms it is better to use two four-plow units on account of the added flexibility of operation. At the same meeting, First Vice-president David Beecroft spoke on the general automotive work of the Society, and Second Vice-president Dent Parrett explained the way in which the Society could be of assistance to the tractor manufacturer. The April meeting will be held on the 26th. One of the speakers will be Mr. Sward, sales engineer of Fairbanks, Morse & Co., who will take as his subject, The Oil Burning Tractor. The other speakers will be announced later.

Pennsylvania Section.—The March meeting of this section will be held on the 28th, at the Engineers' Club of Philadelphia. Mark H. Landis will deliver a paper, Shock Absorbers as Affecting Easy Riding of Passenger Cars and Ambulances.

REPORT OF FEBRUARY COUNCIL MEETING

AT the meeting of the Council held Feb. 25, in Dayton, Ohio, the following were present: President, C. F. Kettering; First Vice-president, David Beecroft; Second Vice-president, C. C. Hinkley; and Councilors B. B. Bachman, C. S. Crawford and C. W. McKinley.

A report was presented by Chairman David Beecroft of the Meetings Committee stating that a successful meeting and dinner had been held Feb. 1, in Chicago, and that a dinner in which much interest was manifested had been held Feb. 13, during the Kansas City Tractor Show.

On the recommendation of Mr. Beecroft, the Council voted that the Semi-Annual (Summer) Meeting of the Society should be held June 17 and 18, in Dayton. It was suggested that professional sessions be held on the 17th, demonstrations of airplanes, tractors, and other types of automotive apparatus on the 18th, and that arrangements be made for the members to visit the factories in Dayton on the 19th, if they so desire.

Second Vice-president Hinkley, as chairman of the Membership Committee, reported that plans had been completed for organizing state committees to handle membership matters during the year. Where section organizations exist in a state their officers are expected to be leaders in the membership work, but in other states members of the Society will be requested to assist.

The Membership Committee of the Society is now completed, and includes, in addition to Chairman Hinkley, the following: Alfred P. Sloan, Jr., Orville Wright, Charles H. John, and T. B. Funk.

It was voted to make the following transfers in grade of membership: From Associate to Member grade, Walter D. Appel, Adna G. Bowen, E. P. Clarkson, Edward A. Field, Howard S. Gardner, Chester S. Moody, Charles B. Page and Francis W. Parker, Jr. The following were transferred from Junior to Member Grade: Ralph E. Chesnutt and Geo. F. Getschman.

Applicants to the number of 88 were elected to membership in the Society, these being assigned to grades as follows: 47 members, 25 associate members, 8 junior members, and 8 student enrollments.

It was announced that Councilor B. B. Bachman had accepted the appointment as chairman of the Standards Committee for the current year. Mr. Bachman presented a report, which was accepted by the Council, showing the personnel of the divisions of the committee that are to be continued, the subjects assigned to these divisions, and also a recommendation for revisions of the regulations governing the work of the Standards Committee. (The contents of this report are given elsewhere in this issue.)

Councilor Crawford reported for the Sections Committee, of which he is chairman, that the possibilities of establishing new sections in Boston, Dayton, Syracuse, San Francisco and Toronto are being investigated. He suggested that standard forms be prepared with the view of their being used by all sections. The Council approved a proposed amendment to the By-Laws of the Cleveland Section, providing that section associates' dues be $10 a year.

President Kettering appointed N. B. Pope of New York a member of the House Committee and N. C. Banks of Detroit a member of the Sections Committee.

On motion, duly seconded, it was voted that paragraph B 14 of the By-Laws of the Society be amended to read as follows:

"The initiation fees and dues for the current annual or semi-annual period shall be due and payable on notice of election to membership, and upon payment the member shall be entitled to the Society's publications for the period. Thereafter the annual dues shall be due and payable on the first day of October in each year.

"An Associate, on being transferred to Member grade, shall pay any difference in initiation fee that may exist between that specified for Member in C 20 and the actual amount paid by the Associate at the time he qualified as such."

In accordance with paragraph C 57 of the Constitution of the Society, which specifies the method for amending the By-Laws, written notice of the above amendment was given at the previous regular meeting of the Council on Jan. 31, and a copy of the proposed amendment was mailed to each member of the Council more than 10 days in advance of the meeting at which the amendment was adopted. The amendment takes effect immediately on its passage by the Council. It is now announced in THE JOURNAL, in accordance with the requirements that this be done in the next publication of the Society.

It was voted to accept, with regret, the resignation of Fred Glover as Second Vice-president to represent tractor engineering. Major Glover is now attached to the Procurement Division of the Ordnance Department of the Army, and cannot, therefore, give what he felt to be the necessary time to the work of the Society.

It was voted that Dent Parrett, chairman of the Tractor Division of the Standards Committee, be elected to fill the vacancy resulting from the resignation of Major Glover.

The next meeting of the Council will be held March 25, at Detroit.

INTER-ALLIED CONFERENCE ON STANDARDS IN LONDON

THE Aircraft Board has announced the arrival in England of delegates from all the allied countries for conference on international standards, at which a standardization of manufacturing materials as related to the production of machinery, engines, aircraft, etc., will be considered.

This conference probably represents the most important development in the field of standardization, and in view of the leading part that the Society has taken in this field it is fitting that it should be well represented in the conference.

The American delegation, headed by F. G. Diffin, of the Aircraft Board, includes members from the prominent engineering societies of the country. There are also representatives of the Aircraft Board, the Advisory Committee for Aeronautics, the Signal Corps, the Navy, and the original International Aircraft Standards Board, from which this conference is an outgrowth.

Following is a list of the American members in attendance at the conference who are members of the S. A. E.: F. G. Diffin (chairman); General Manager Coker F. Clarkson; Edwin H. Ehrman, chairman of the Miscellaneous Division of the S. A. E. Standards Committee; Councilor Charles M. Manly, chairman of the Aeronautical Division of the Standards Committee; James Hartness, and F. G. Ericson. The other members of the American delegation are: Dr. W. F. Durand, Lieut. Commander Benjamin Briscoe, Lieut. W. F. Prentice, Albert L. Colby, Capt. A. B. Tilt and F. R. Baxter.

The Aircraft Board's statement says that the purpose of this inter-allied meeting, which is the result of the efforts of Mr. Diffin, is to enable better industrial service to be given with less man-hour effort, through relieving plants from carrying in stock unstandard materials for which there is small call, and concentrating on materials of known performance for the same work. No attempt will be made by the conference to standardize airplane constructions, but rather those materials and units which are at present causing confusion in purchase and delivery, and for which suitable standards can be established.

PERSONAL NOTES OF THE MEMBERS

THE S. A. E. Membership List for 1918 is now in course of preparation and a notice has been sent to the members requesting data covering business connections, articles manufactured, and branches of automotive engineering of chief interest to them. Members are urgently requested to forward the information requested not later than April 15. Furthermore, the Society desires to be advised from time to time as to changes in positions and connections of the members, in order to keep its membership informed, and will therefore appreciate any information of this nature.

Jos. A. Anglada is now president of the Commercial Car Unit Co., Philadelphia.

M. Reed Bass is now supervisor of gas-engine work and evening school principal, Dunwoody Industrial Institute, Minneapolis.

R. E. Benner, formerly general superintendent, Buick Motor Co., Flint, Mich., is now factory manager, H. H. Franklin Mfg. Co., Syracuse, N. Y.

A. H. Bowlzer, Jr., formerly chief draftsman, Hydraulic Pressed Steel Co., Cleveland, is now with the Parish & Bingham Co. of Cleveland.

F. A. Bower, formerly chief engineer, Weston-Mott Co., is now engineer, Buick Motor Co., Flint, Mich.

Wallace B. Blood, formerly general manager, Williams Motors Co., Chicago, is now manager, Wallace B. Blood, Automotive Service, at Chicago.

J. F. Coyle, formerly at Penfield, Ill., is now designer of special machinery, Western Cartridge Co., Alton, Ill.

Jerry W. De Cou has severed his connections as factory manager of the Smith Motor Truck Corp., Clearing, Ill.

W. A. Dick, formerly engineer, is now commercial engineer of the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., at New York.

G. V. Domarus, Jr., formerly body engineer, Service Motor Truck Co., Wabash, Ind., is now chief engineer, Universal Lug Co., Cicero, Ill.

Stephen D'Orlow, formerly doing special engineering work for Republic Motor Truck Co., and chief engineer, Oak Mfg. Co., Alma, Mich., is now research engineer with Republic Motor Truck Co. of Alma, Mich.

Geo. W. Dunham, vice-president, The Militor Corp., New York, is now at Jersey City.

W. E. Dunston, formerly chief engineer, Standard Parts Co., Cleveland, is now with Crown Hardware Mfg. Co., Dayton.

O. C. Friend, formerly president, Mitchell Motors Co., Racine, Wis., is now vice-president, United Motors Corp, New York.

Karl Feilche, formerly cnief engineer, The Pathfinder Motor Co. of America, Indianapolis, now holds the same position with the Automotive Engineering Co., Indianapolis.

Roy C. Fryer, formerly specialist in starting, lighting and ignition, The Leyman-Buick Co., Cincinnati, is now in charge of shops, Boyle Engineering Co., Cincinnati.

D. T. Fraser, formerly engineer with Drexel Motor Car Corp., Chicago, is now designing engineer with the Bonner-Charter Motor Co., Chicago.

H. J. Guthrie, formerly president, Platt & Washburn Refining Co., New York, is now manager, Veedol department, Tide Water Oil Co., New York.

G. Brewer Griffin, manager, auto equipment department, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., is now at New York.

Albert B. Gomory, formerly production engineer, Hen-

dee Mfg. Co., Springfield, Mass., is now with Splitdorf Electrical Co., Newark, N. J.

E. G. Gunn, formerly production engineer, Q. M. C., U. S. A., Washington, is now engineer with The Aluminum Castings Co., Cleveland.

Geo. T. Homeier, formerly superintendent, Remington Arms & Ammunition Co., Bridgeport, Conn., is now superintendent, Worcester Mfg. Co., Worcester, Mass.

Arnold J. Halbfass, formerly mechanical engineer at Princess Bay, Staten Island, New York, is now with the George Haiss Mfg. Co., New York.

Wm. G. Henderson, formerly engineer and production manager, Henderson Motorcycle Co., Detroit, is now superintendent, Excelsior Motor Mfg. & Supply Co., Chicago.

Ralph Hitchcock, formerly salesman, Buck Motor Car Co., Davenport, Iowa, is now salesman with the Orr Motor Sales Co., Omaha, Neb.

Herbert A. Hansen, formerly engineer and designer, C. L. Best Gas Traction Co., San Leandro, Cal., is now with the Holt Mfg. Co., Peoria, Ill.

Penrose R. Hoopes, formerly draftsman, Andrew C. Campbell, Inc., Waterbury, Conn., is now designer, Stokes & Smith, Summerdale, Pa.

W. A. Haines, formerly salesman, Westinghouse Elec. & Mfg. Co., East Pittsburgh, is now assistant to manager, Detroit sales division, at Detroit.

H. M. Jerome, formerly assistant chief engineer, Chalmers Motor Co., Detroit, is now chief engineer, Chalkis Mfg. Co., Detroit.

Elbert J. Jenkins, formerly president and general manager, The Four Drive Tractor Co., Big Rapids, Mich., is now with The Dow Chemical Co., Midland, Mich.

J. A. Kingsbury, metallurgist, formerly with the Studebaker Corp., South Bend, Ind., is now with the Trego Motors Corp, New Haven, Conn.

Geo. W. Kerr, formerly body engineer, Reo Motor Car Co., Lansing, Mich., is now manager, body plant, Mitchell Motors Co., Inc., Racine, Wis.

H. E. Krause, formerly plant manager, Wire Wheel Corp. of America, Buffalo, N. Y., is now assistant general manager in charge of production, Splitdorf Electrical Co., Newark, N. J.

Thomas H. Lynn, formerly sales manager, Lycoming Foundry & Mfg. Corp., Williamsport, Pa., is now mechanical engineer, National Mfg. Corp., Williamsport, Pa.

G. Harold Lewis, assistant manager, auto equipment department, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., is now at New York.

B. B. Larzelere, formerly president and general manager, Tourine Motors Co., Philadelphia, is now vice-president and general manager, Vim Motor Truck Co., of the same city.

S. D. Levings, formerly Eastern district manager of sales, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., is now with Columbian Bronze Corp., New York.

H. S. McClellan, formerly general superintendent, Chalmers Motor Co., Detroit, is now superintendent Plant No. 1, Buick Motor Co., Flint, Mich.

Geo. C. McMullen, formerly assistant plant manager, Timken-Detroit Axle Co., Detroit, is now Pacific Coast sales engineer, Timken Roller Bearing Co., at San Gabriel, Cal.

Edward Maurer, formerly chief engineer, Monroe Motor Co., Pontiac, Mich., is now superintendent of shops, The Solvay Process Co., Detroit.

C. S. Miller, formerly engineer, Prest-O-Lite Co., Inc., Toronto, Canada, is now owner and manager, Hamilton Battery Service Co., Hamilton, Canada.

E. E. Main, formerly with Rajah Auto Supply Co., Indianapolis, is now experimental engineer, Eclipse Mfg. Co., at Indianapolis.

H. F. Patterson has severed his connection as chief engineer of the Erie Motors Cultivator Co., Erie, Pa.

Louis A. Prince, formerly special sales representative, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., at Sumter, S. C., is now proprietor of the Prince Mfg. Co. of that city.

L. C. Reynolds, formerly manufacturing superintendent, General Vehicle Co., Long Island City, is now with the General Motors Co., Detroit.

George E. Read, formerly general manager, T. Elliott Rourke & Co., Santiago, Chile, is now manager, Pratt & Co., Buenos Aires, Argentina.

John F. Reno, formerly chief draftsman, Moline Automobile Co., East Moline, Ill., is now chief engineer of auto and motor department, Root & Van Dervoort Engineering Co., East Moline, Ill.

Louis Schwitzer, formerly production manager, The Oakes Co., Indianapolis, is now president, Automotive Parts Co., Indianapolis.

E. P. Smith, formerly engineer, Hercules Motor Mfg. Co., Canton, Ohio, is now in engineering department, Garford Motor Truck Co., Lima, Ohio.

Turner Smith, formerly managing director, Anzac Motor Co., Ltd., London, England, is now managing director, Ancona Motor Co., Ltd., London, England.

John W. Son, Jr., formerly salesman, Western Spring & Axle Co., Cincinnati, is now foreman, Remington Arms Co., Ilion, N. Y.

L. C. Smith, formerly superintendent and secretary, American La France Fire Engine Co., Elmira, N. Y., is now with the O. J. Childs Co., Utica, N. Y.

Fred C. Seeger, Jr., salesman and consulting engineer of the Doehler Die-Casting Co., Toledo, is now at Detroit.

C. D. Turner has severed his connections as engineer, storage battery department, The Prest-O-Lite Co., Indianapolis, and is now located at 620 State Life Bldg., Indianapolis.

Austin M. Wolf has severed his relations as designing engineer with the American Motors Corp., Plainfield, N. J.

L. E. Wood, formerly designer, Cadillac Motor Car Co., Detroit, is now assistant chief engineer, Mitchell Motors Co., Racine, Wis.

H. A. Wagner, formerly manager, Beam Fletcher Corp., Philadelphia, Pa., is now general manager, Chicago, Waukegan & Hammond Transportation Co., Chicago.

HONOR ROLL OF SOCIETY MEMBERS

THE following members have recently entered the services of the government in civilian or military capacities. This list, together with the "Service Directory of Members" following, is intended to contain the names of all members connected with the Government, either in the military services or in civilian capacities. In both the "Honor Roll" and the "Service Directory" the names are listed in two parts, the first showing the members who have actually entered the military services, and the second those engaged as civilians. Every effort is made to have the addresses correct, but many of the members are changing about so much that it is almost impossible to tell accurately as to just where they are located at any given time. It is therefore requested, in case of any error, that the member concerned immediately inform the New York office of the Society, so that a proper correction can be made. Members who have actually entered the service in any capacity, and who are not listed, should also write the details to the New York office.

Military Service

Bates, Wm. O., Jr., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance R. C., Washington.

Coffman, Don M., first lieutenant, Aviation Section, Signal R. C., Commercial Bldg., Dayton, Ohio.

Campbell, Archibald F., Aviation Section, Signal R. C., Washington.

Clark, Elmer J., captain, Signal R. C., Buffalo, N. Y.

Cockrill, Emmet, first lieutenant, U. S. A., Detroit, Ordnance Department, Production Division, Carriage Sect.

Dahlquist, Chas S., major, Quartermaster Department, U. S. N. A., Washington, assigned to Inspection Division as supervisor of inspection on standardized military trucks.

Denison, Arthur H., cadet, School of Military Aeronautics, Massachusetts Institute of Tech., Cambridge, Mass.

Engesser, Benj. M., School of Military Aeronautics, Massachusetts Institute of Technology, Cambridge, Mass.

Fitzgerald, Gerald, second lieutenant, Motor Truck Co. 348, Camp McArthur, Texas.

Foster, William J., second lieutenant, Signal R. C., U. S. A., Washington, assigned to Engine Design Section, Airplane Engineering Department, Aviation Section.

Gray, Samuel W., first lieutenant, Signal Corps, U. S. A., Washington, assigned to 4th Co., 2d Motor Mechanics Regiment, Ground Division, Aviation Section.

Hobbs, J. W., first lieutenant, Ordnance R. C., U. S. A. (mail), Holt Mfg. Co., Peoria, Ill.

Hull, M. Lair, private, Ordnance Department, U. S. A., Washington, assigned to Trench Warfare Unit, Requirement Section, Control Bureau.

Houston, Harold S., 3d Officers' Training Co., Fort Munroe, Va.

Hoyt, F. R., lieutenant, Aviation Section, Signal R. C., Washington.

Junk, Fred H., cadet, U. S. Army School of Military Aeronautics, Mass. Inst. of Tech., Cambridge, Mass.

Jaco, E. L., captain, Engineer R. C., U. S. A., Washington, assigned to General Engineering Depots.

Kalb, Lewis P., major, Quartermaster Corps, U. S. N. A., Washington.

Klemin, Alexander, sergeant, Signal Corps, U. S. A., McCook Field, Dayton, Ohio; assigned to research, Airplane Engineering Department, Aviation Section.

Mitchell, C. B., lieutenant, 4th Motor Mechanics' Regiment, Camp Hancock, Ga.

Miller, Donald G., first lieutenant, Ordnance R. C., U. S. A. (mail), Nash Motors Co., Kenosha, Wis.

Matthews, Meredith, private, Ordnance Motor Instruction School, U. S. A., Camp Herring, Peoria, Ill., assigned as auto expert.

Norris, G. L., captain, Signal R. C., U. S. A., Pittsburgh, Pa.

Pierce, Hugh M., first lieutenant, Signal R. C., Call Field, Wichita Falls, Texas, assigned as engineer officer, Aviation Section.

Peterson, F. Somers, ensign, Naval Air Station, San Diego, Cal.

Riddle, E. C., cadet, Gerstner Field, Lake Charles, La.

Ritter, E. R., first lieutenant, Ordnance R. C., U. S. A., Washington, assigned to Production Division, Carriage Section.

Rumney, Mason P., captain, Production Division, Ordnance R. C., Washington.

Rounds, Edward W., U. S. N. R., U. S. Naval Aviation Detachment, Cambridge, Mass.

Shafer, M. S., second lieutenant, Signal R. C., McCook Field, Dayton, Ohio, assigned to Airplane Eng. Div.

Smith, Edson H., ensign, U. S. N. R. (mail) American & British Mfg. Co., Bridgeport, Conn., assigned as assistant naval inspector of Ordnance.

Taylor, Paul B., sergeant, Medical Corps, U. S. A., Pontiac, Mich.

Taylor, S. G., Jr., first lieutenant, Signal R. C., Washington, assigned to Motor Equipment Section.

Workman, Lee W., 670th Aero Squadron, Aviation Branch, Morrison, Va.

Civilian Service

Adams, H. J., War Industries Board, Washington.

Anderton, H. C., aeronautical mechanical engineer, Production Engineering Department, Equipment Division, Signal Corps, U. S. A., Lindsey Building, Dayton, Ohio.

Barton, Chas. E., Signal Corps, U. S. A., McCook Field, Dayton, Ohio, assigned to Airplane Eng. Department.

Barnaby, Ralph S., airplane inspector, Naval Reserve Flying Corps, Buffalo, N. Y.

Griffith, Leigh M., technical expert, National Advisory Committee for Aeronautics, Lindsey Bldg., Washington.

Horning, H. L., chairman, Automotive Products Section, War Industries Board, Washington.

Moorhouse, A., Signal Corps, U. S. A., Lindsey Bldg., Dayton, Ohio, assigned as engineer in Airplane Eng. Dept.

Rymarczick, Gustav M., Signal Corps, U. S. A. (mail), Splitdorf Electrical Co., Newark, N. J., assigned to Aviation Sect., as senior inspector, Signal Service at Large.

Stuart, H. R., Signal Corps, U. S. A., Lindsey Building, Dayton, Ohio, assigned as aeronautical mechanical engineer, Production Engineering Department.

Simpson, Howard W., Signal Corps, U. S. A., Detroit, assigned as inspector of aircraft engines, Inspection Section, Equipment Division.

Schaum, Otto W., Signal Corps, U. S. A., Lindsey Building, Dayton, Ohio, assigned as aeronautical mechanical engineer, Production Engineering Department.

Vohrer, W. R., Quartermaster Corps, U. S. A., Signal R. C., Washington, assigned as draftsman.

Waldon, C. O., National Bureau of Standards, Washington, assigned as laboratory assistant, Military Research Gas Engines.

Younger, John, Quartermaster Corps, U. S. A., Washington, assigned to Motor Transportation Engineering Office, as supervisor of engineering.

Service Directory of Members

Military Honor Roll

Alden, Herbert W., lieutenant-colonel, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

Aldrin, Edwin E., lieutenant, Coast Artillery Corps, U. S. A., *Ft. Monroe, Va.*, (mail) 2nd Training Co., *Ft. Monroe, Va.*

Amon, Carl H., Aviation Section, Signal R. C., *Washington.*

Anderson, Oscar G., private, 161st Depot Brigade, Co. 4, U. S. N. A (mail) Barracks 1488W, Camp Grant, Ill.

Anderson, E. S., lieutenant, Aviation Section, Signal Corps, U. S. A., *Gerstner Field, La.*

Anderson, William C., lieutenant, Engineer R. C., *Brooklyn, N. Y.*

Arnold, Bion J., lieutenant colonel, Aviation Section, Signal R. C., *Washington.*

Barker, C. Norman, pilot cadet, Royal Flying Corps, *Camp Borden, Can.*

Barton, W. E., first lieutenant, Quartermaster R. C., *Washington.*

Bibb, John T., Jr., private, Aviation Section, Signal Corps, A. E. F., France; (mail) 3rd Foreign Detachment, Cadet Flying Squadron, A. E. F., *France.*

Blank, M. H., first lieutenant, Motor Equipment Division, Ordnance R. C., Grant Motor Car Co., *Cleveland.*

Blood, Howard E., lieutenant, Engine Design Section, Equipment Division, Signal Corps, U. S. A., *Washington.*

Boggs, Geo. A., lieutenant, Quartermaster Corps, U. S. A.; (mail) Farmers Loan & Trust Co., *Paris, France.*

Bowen, C. H., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

Britten, Daniel L., captain, Ordnance R. C., Washington, assigned to Gun Division, Ordnance Section.

Britten, Wm. M., major, engineer of motor transportation, Quartermaster R. C., *Washington.*

Brown, Julian S., U. S. A., (mail) Aviation School, Massachusetts Institute of Technology, *Cambridge, Mass.*

Brown, Harold Haskell, first lieutenant, Coast Artillery Corps, U. S. N. A., *Fort Totten, N. Y.*

Browne, Arthur B., captain, Sanitary Corps, U. S. N. A., (mail) General Motors Co., *Detroit.*

Callan, John Lansing, lieutenant, Reserve Flying Corps, U. S. N., U. S. S. Seattle, (mail) Postmaster, *New York.*

Campbell, Lindsey F., 4th Battery, 2d P. T. R., *Fort Sheridan, Ill.*

Chase, A. M., major, Ordnance Department, U. S. A., *Washington.*

Clark, Edward L., first lieutenant, Signal R. C., McCook Field, *Dayton, Ohio.*

Clark, Virginius E., lieutenant colonel, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

Coe, Edw. M., first lieutenant, Quartermaster Corps, U. S. A., *Washington*, (mail) Mechanical Repair Shops No. 302, A. E. F., *France.*

Dayton, William E., private, 306th Regiment, Field Artillery, U. S. N. A., *Washington.*

Deeds, Edward A., colonel, Equipment Division, Signal Corps, U. S. A., State, War and Navy Bldg., *Washington.*

De Lorenzi, Ernest A., officer, Mechanical Transport, War Department, *London, Eng.*

De Witt, George W., lieutenant, U. S. Naval Militia, *Jacksonville, Fla.*

Diamond, J. E., captain, Ordnance R. C., *Peoria, Ill.*

Dickey, Herbert L., captain, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

Dimond, G. A., first lieutenant, Motor Section, Ordnance R. C., Ft. Herring, *Peoria, Ill.*

Donaldson, Frank A., captain, Carriage Division, Ordnance R. C., Sixth and B. Sts., *Washington.*

Dost, Charles O., first lieutenant, Aviation Section, Signal Corps, U. S. A., Cornell University, *Ithaca, N. Y.*

Du Bose, Geo. W. P., major, American Ordnance Base Depot, A. E. F., *France.*

Duncan, A. C., first lieutenant, Balloon Co. No. 7, Signal Corps, Aviation Section, Signal R. C., (mail) A. E. F., *France.*

Duntley, Lloyd B., first lieutenant, Ordnance R. C., Washington, assigned to Engineering Motor Equipment Section.

Earle, Lawrence H., first lieutenant, Ordnance R. C., assigned as inspector of ordnance, Holt Mfg. Co., *Peoria, Ill.*

Eells, Paul W., lieutenant, 330th Field Artillery, Artillery R. C., Camp Custer, *Battle Creek, Mich.*

English, C. H., Jr., first lieutenant, Ordnance R. C., *Washington.*

Farrell, Matthew, captain, Quartermaster R. C., *Washington.*

Finkenstaedt, Edward R., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

Fishleigh, W. T., major, Sanitary Corps, U. S. N. A., *Washington*, assigned as automobile engineer.

Flanigan, E. B., Officers' Reserve Training Camp, *Plattsburg, N. Y.*

Fliedner, Carlyle, captain, Motor Section, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.*

Forrer, J. D., captain, Engineer R. C., *Washington.*

Foss, Clarence M., captain, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section.

Fox, Rudolph H., first lieutenant, Ordnance R. C., *Washington.*

Franklin, G. King, captain, Motor Section, Ordnance R. C., *Washington.*

Furlow, James W., lieutenant colonel, Quartermaster Corps, U. S. A., *Washington*, assigned to Office of Quartermaster General.

Gaebelein, Arno W., lieutenant, Ordnance R. C., *Washington*, assigned to Carriage Division.

Gardner, Lester D., captain, 117th Aero Squadron, Signal Corps, U. S. A., *Washington.*

Getschman, G. F., second lieutenant, Ordnance R. C., *Washington.*

Gey, William, 377th Truck Train, U. S. N. A., Camp Merritt, *Tenafly, N. J.*

Gfroerer, A. H., first lieutenant, Ordnance R. C., *Washington.*

Gillis, Harry A., major, Ordnance R. C., *Washington.*

Glover, F. S., major, Ordnance R. C., *Washington.*

Gorrell, Edgar S., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., Washington, (mail) Frank E. Gorrell, National Canners' Asso., 17th and H sts., *Washington.*

Graham, Louis, lieutenant, 309th Engineers, Engineers R. C., *Camp Zachary Taylor, Ky.*

Gray, B. D., major, Equipment Division, Aviation Section, Signal R. C., Lindsey Bldg., *Dayton, Ohio.*

Green, Geo. A., captain, Tank Section, British E. F., *France.*

Guthrie, James, major, Ordnance R. C., *Washington*, assigned to Field Artillery Section, Carriage Division.

Haeske, F. C., lieutenant, U. S. A., Camp Sherman, *Chillicothe, Ohio.*

Hall, Elbert J., major, Engine Design Section, Engineering Division, Signal Corps, U. S. A., *Washington.*

Hall, Richard H., Jr., first lieutenant, Quartermaster Corps, U. S. N. A., *Washington.*

Harms, Henry W., captain, Aviation Section, Signal Corps, U. S. A., *Washington.*

Hartman, A. A., private, U. S. N. A., Camp Devens, *Ayer, Mass.*

Hegeman, Harry A., major, Quartermaster Corps, U. S. A., *Washington*, assigned to office of Officer in Charge of Transportation.

Henderson, S. W., first lieutenant, Ordnance R. C., *Washington.*

Hoffman, Roscoe C., captain, Carriage Division, Motor Equipment Section, Ordnance R. C., *Washington.*

Horine, M. C., second lieutenant, Aviation Section, Signal R. C., *Washington.*

Horner, Leonard S., major, Equipment Division, Signal Corps, U. S. A., *Washington.*

Howard, Walter S., first lieutenant, Military Truck Production Section, office of Quartermaster General, *Washington.*

Hubbell, Lindley D., lieutenant colonel, U. S. N. A., Ordnance Department, *Springfield, Mass.*, assigned as Officer in Charge, Hill Shops, Springfield Armory.

Jeffrey, Max L., first lieutenant, Military Truck Production Section, Office of Quartermaster General, *Washington.*

Jennings, J. J., first lieutenant, Quartermaster R. C., A. E. F., *France.*

Joy, Henry B., lieutenant colonel, 4th Motor Mechanics Regiment, Signal Corps, U. S. A., *Camp Hancock, Ga.*

Kendrick, John F., Signal Corps, A. E. F., *France*, assigned to Research Inspection Division.

Kennedy, H. H., lieutenant, Ordnance Department, U. S. A., *Washington*, assigned as inspector of ordnance.

Kline, H. J., first lieutenant, Ordnance R. C., *Washington*, assigned to Anti-Aircraft Section, Carriage Division.

Kohr, Robert F., second lieutenant, Engineers R. C., *Washington.*

Kottnauer, Edwin H., first lieutenant, Ordnance R. C., assigned to The Nash Motors Co., *Kenosha, Wis.*

Lane, Abbott A., first lieutenant, Aviation Section, Signal R. C., *Detroit, Mich.*

Lanza, Manfred, major, Quartermaster Corps, U. S. A., headquarters 78th Division, *Camp Dix, N. J.*

Larsen, Lester Reginald, second lieutenant, Engineer R. C., *Washington.*

Lavery, Geo. L., Jr., first lieutenant, Ordnance R. C., *Washington.*

Lay, Arthur J., captain, Aviation Section, Signal R. C., *Washington.*

LeFevre, Wm. G., lieutenant, Ordnance R. C., *Washington.*

Lewis, Charles B., captain, Ordnance R. C., Camp Lewis, *American Lake, Wash.*

Lewis, Harry R., Jr., first lieutenant, Ordnance R. C., Springfield Armory, *Springfield, Mass.*

Libbey, E. B., lieutenant, 2nd Caisson Co., 102nd Ammunition Train, U. S. N. A., *Spartanburg, S. C.*

Lipsner, B. B., captain, Air Division, Aviation Section, Signal R. C., *Washington.*

McCormick, Bradley T., captain, Ordnance Department, U. S. A., *New York.*

McGill, Geo. E., Co. B., 85th Division Military Police, Camp Custer, *Battle Creek, Mich.*

McIntyre, H. C., captain, Ordnance R. C., *Washington.*

McMurtry, Alden L., captain, office of Surgeon General, Sanitary Corps, U. S. N. A., *Washington.*

Mackie, Mitchell, major, Quartermaster Corps, U. S. A., A. E. F., *France*, assigned to Motor Truck Transport Section.

Marmon, Howard, major, Airplane Engineering Division, Signal R. C., McCook Field, *Dayton, Ohio.*

Marshall, W. C., captain, Ordnance R. C., *Washington.*

Martin, Kingsley G., captain, Quartermaster R. C., *Camp Dodge, Iowa.*

Mason, Geo. R., lieutenant, A. E. F., *France.*

May, Henry, Jr., first lieutenant, Military Truck Production Section, Office of Quartermaster General, *Washington.*

May, O. J., captain, Aviation Section, Signal R. C., Camp Custer, *Battle Creek, Mich.*

Mergi, William, Co. B., First Battalion, 153d Depot Brigade, Camp Dix, *Wrightstown, N. J.*

Middleton, Ray T., first lieutenant, Air Service, A. E. F., *Paris, France.*

Miller, B. F., major, Quartermaster Corps, U. S. A., *Washington.*

Miller, C. A., first lieutenant, Quartermaster Corps, U. S. N. A., *Washington.*

Moffat, Alex. W., ensign, commanding U. S. S. "Tamarack" (S. P. 561), Naval Defense Reserve, Postmaster, Foreign Station, *New York.*

Moncrieff, V. I., captain, Aviation Section, Signal R. C., *Washington.*

Morgan, M. B., captain, Ordnance R. C., *Washington.*

Murphy, Joseph G., Sanitary Corps, U. S. N. A., *Washington.*

Myers, J. L., first lieutenant, Ordnance R. C., *Washington.*

Nahikian, S. M., lieutenant, Aviation School, Massachusetts Institute of Technology, Cambridge, Mass.

Oldfield, Lee W., captain, Signal R. C., *Washington*, assigned as aeronautical engineer.

Ommundson, H. P., Flying Corps, U. S. N., Aeronautic Station, *Pensacola, Fla.*

Orton, Edward, Jr., major, Quartermaster R. C., Washington, assigned to Motor Transport Branch, Engineering Section.

Otto, Henry S., lieutenant, Intelligence Section, A. E. F., *France.*

Pagé, Victor W., first lieutenant, Aviation Section, Signal R. C., *Mineola, N. Y.*

PAINE, C. L., captain, Ordnance R. C., *Washington.*
PARKER, RICHARD E., captain, Quartermaster R. C., *Washington,* assigned to Southern Department.
PEARMAIN, W. J., captain, Ordnance R. C., A. E. F., *France.*
PEIFER CARL B., lieutenant, Specification Section, Signal Corps, U. S. A., *Washington.*
PFEIFFER, BEN. S., first lieutenant, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.,* assigned to Motor Section.
POST, EDWIN M., JR., lieutenant, U. S. Air Service, A. E. F., *France.*
POTTER, AUSTIN E., lieutenant, U. S. N. R. F., U. S. Naval Aviation Forces, *France.*
POWELL, W. B., captain, assigned as officer in charge of mechanical transport, Imperial Ministry of Munitions, *Quebec, Can.,* (mail) P. O. Box 194.
PULLEN, DANIEL D., major, 7th Regiment, Engineer Corps, U. S. A., A. E. F., *France.*
PURCELL, BERNARD A., captain, Quartermaster R. C., 307th Supply Train, Camp Gordon, Ga., assigned as Commanding Officer.
RANNEY, A. ELLIOT, major, Air Division, Signal Corps, U. S. A., *Washington.*
RAWLEY, JOS., captain, Co. A., 310th Engineers, U. S. A., Camp Custer, *Battle Creek, Mich.*
ROBINSON, H. A., ensign, N. R., U. S. N., *Keyport, N. J.*
ROSE, CHARLES B., major, Equipment Division, Signal Corps, U. S. A., *Washington.*
ROSENTHAL, WM. C., sergeant, Engineer O. T. C., *Camp Lee, Va.*
RUSSELL, EUGENE F., major, Ordnance Department, U. S. A., *Washington.*
SANDT, A. R., sergeant, Ordnance Department, U. S. A., Rock Island Arsenal, *Rock Island, Ill.,* assigned to Motor Section Instruction School.
SCHOENFUSS, F. H., captain, Production Section, Ordnance R. C., *Washington.*
SCHOEPF, T. N., captain, Engineer R. C., *Washington.*
SCOTT, ALLISON F. H., captain, Signal Corps, U. S. A., Langley Field, *Hampton, Va.,* assigned to Aviation Section.
SELFRIDGE, S. W., first lieutenant, Ordnance R. C., *Washington.*
SLADE, ARTHUR J., captain, Aviation Section, Signal R. C., *Washington.*
SMITH, FRANK E., major, Signal Corps, U. S. A., *Washington.*
SMITH, MARK A., first lieutenant, Marine Corps, U. S. N., *Washington.*
SPRAGUE, G. A., Co. D., 310th Engineers, Camp Custer, *Battle Creek, Mich.*
STEINAU, J. M., private, Sanitary Corps, U. S. N. A., *Washington.*
STRAHLMAN, OTTO E., first lieutenant, Aviation Section, Signal R. C., (mail) McCook Field, *Dayton, Ohio.*
STRAUSS, N. FRANK, lieutenant, Ordnance R. C., *Washington.*
STREICHER, GEO. A., 11th Co., Engineer O. T. C., *Camp Lee, Va.*
STREETER, ROBT. L., major, Ordnance Department, U. S. A., *Rock Island Arsenal, Ill.,* in charge of truck and tractor experimental work.
SWEET, GEO. P., first lieutenant, Signal Corps, U. S. A., Washington, assigned to Aviation Section.
SWINTON, D. R., first lieutenant, Quartermaster Corps, U. S. A., assigned to office of Quartermaster General.
TEETOR, D. C., captain, Ordnance R. C., *Kenosha, Wis.,* assigned to Motor Section.
THOMPSON, H. E., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*
THOMSON, CLARKE, lieutenant, Signal R. C., *Washington.*
TITSCH, WALTER H., captain, Quartermaster Corps, U. S. N. A., A. E. F., *France.*
TOLMAN, EDGAR BRONSON, JR., first lieutenant, 311th Engineers, U. S. A., Camp Grant, *Rockford, Ill.*
TURNER, HARRY C., captain, Engineer R. C., A. E. F., *France.*
TWACHTMAN, QUENTIN, first lieutenant, Engine Design Section, Signal R. C., *Washington.*
UNDERHILL, C. R., captain, Radio Section, Signal R. C., *Washington.*
VAIL, E. L., lieutenant, Signal Corps, U. S. A., *Washington.*
VERITY, CALVIN W., captain, Ordnance R. C., Frankfort Arsenal, *Philadelphia.*
VINCENT, JESSE G., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., Miami Hotel, *Dayton, Ohio.*
VONACHEN, F. J., lieutenant, Ordnance Department, U. S. N. A., Rock Island Arsenal, *Rock Island, Ill.*
WALDON, SIDNEY D., colonel, Equipment Division, Signal Corps, U. S. A., *Washington.*
WALL, WILLIAM GUY, major, Ordnance R. C., *Washington,* assigned to motorization work.
WALTER MAURICE, first lieutenant, Ordnance R. C., *Washington.*
WALTON, FRANK, acting sergeant, Quartermaster Corps, U. S. A., Quartermaster Repair Unit, (mail) *Washington, D. C.*
WETHERILL, S. P. JR., major, Quartermaster R. C., *Washington.*
WHITTENBERGER, OWEN M., first lieutenant, Ordnance R. C., *Washington,* assigned to Office of Chief of Ordnance.
WILSON, T. S., lieutenant colonel, First Indiana Field Artillery, *Santa Fe, N. M.*
WODEHOUSE, B. A., sergeant, Co. A, 339th Infantry, *Camp Custer, Mich.*
WOOD, HAROLD F., lieutenant, Specification Section, Equipment Division, Signal R. C., *Washington.*
WOODS, S. H., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*
YONKIN, HARRY F., first lieutenant, Ordnance R. C., A. E. F., *France.*

CIVILIAN HONOR ROLL

ADAMS, PORTER H., Office of the Section Commander, First Naval District, *Rockford, Me.*
AGINS, HERMAN J., Quartermaster Engineering Department, War Department, *Washington.*
ANDERSON, E. S., mechanical engineer, Aviation Section, Signal Corps, U. S. A., Rockwell Field, N. Island, *San Diego, Cal.*
BARE, ERWIN L., automobile body designer, Office of Quartermaster General, *Washington.*
BARNHARDT, GEO. E., aeronautical mechanical engineer, Signal Corps, U. S. A., Wilbur Wright Field, *Dayton, Ohio.*
BELLING, G. C. C., assistant inspector of engineering material, U. S. Navy Department, *Buffalo, N. Y.*
BOOTH, FRED C., draftsman, Motor Transport Division, Quartermaster Department, U. S. A., *Washington.*
BOURQUIN, J. F., supervisor of chassis assembly, Military Truck Production Section, Office of Quartermaster General, *Washington.*
BRADFIELD, E. S., Engineering Department, Naval Factory, *Philadelphia.*
BURTON, W. DEAN, aeronautical mechanical engineer, Signal Corps, U. S. A., *Fort Omaha, Neb.*
CALDWELL, FRANK W., aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington,* (mail) 1449 Massachusetts Avenue, N. W.
CHAPMAN, ROBERT H., U. S. N., Spartanburg, S. C., assigned to Aeronautical Division.
CHAUVEAU, ROGER, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*
CHERRY, RALPH E., Signal Corps, U. S. A., McCook Field, Dayton, Ohio, assigned to Airplane Engineering Department.
CLARK, ELMER J., Signal Corps, U. S. A., *Portland, Ore.,* assigned as district manager of inspection.
CLARKE, THOMAS A., Signal Corps, U. S. A., Washington, assigned to Aviation Section as production expert.
CLEAVER, B. J., Medical Corps, U. S. A., *Fort Oglethorpe, Ga.*
COFFIN, HOWARD E., chairman, Aircraft Production Board, *Washington.*
COSTELLO, JOHN V., aeronautical engineer, airplane engineering division, Signal Corps, *Dayton, Ohio.*
DEKLYN, JOHN H., technical assistant, National Advisory Committee on Aeronautics, *Washington.*
DICK, ROBERT I., motor truck expert, Ordnance Department, Camp Dodge, *Iowa.*
DIFFIN, F. G., chairman, International Aircraft Standards Board, *Washington.*
DUVAL, EUGENE C., Signal Corps, U. S. A., assigned to Airplane Engineering Department, *Dayton, Ohio.*
EDGERTON, A. H., aeronautical mechanical engineer, Inspection Section, Signal Corps, U. S. A., assigned to Equipment Division.
EDMONDSON, D. E., U. S. Signal Service at Large, *Washington,* assigned as inspector of airplanes and airplane engines, Ericsson Mfg. Co., *Buffalo.*
EISELE, WILLIAM S., draftsman, Aviation Section, Signal Corps, U. S. A., *Washington.*
ELLIOTT, E. M., U. S. Public Service Reserve, Department of Labor, 1712 I Street, *Washington.*
ERICSON, FRIEHOF G., representative of Canada, International Aircraft Standards Board, *Washington.*
FERRY, PHILLIPS B., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*
FOWLER, HARLAN D., aeronautical engineer, Aviation Section, Signal Corps, *Washington.*
FROESCH, CHARLES, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*
GILL, R. O., inspector of airplanes, Equipment Division, Signal Corps, (mail) Dayton-Wright Airplane Co., *Dayton, Ohio.*
GIRL, CHRISTIAN, director, Military Truck Production Section, Office of Quartermaster General, *Washington.*
GRIMES, C. P., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned to airplane engineering department.
GORMAN, E. J. B., U. S. Flying Corps, N. R., U. S. N., *Dayton, Ohio,* assigned to inspection of airplane engines, Dayton-Wright Aeroplane Co.
GUERNSEY, CHAS., Quartermaster Corps, U. S. A., *Washington,* assigned to Motor Transportation Board.
HALE, W. A., aeronautical mechanical engineer, Signal Corps, U. S. A., *Dayton, Ohio.*
HALLETT, GEO. E. A., aeronautical mechanical engineer, Signal Corps, Aviation School, *San Diego, Cal.*
HARRIGAN, F. P., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned to Plane Design Section.
HECKEL, C. E., truck designer, Transport Division, Quartermaster Corps, U. S. A., *Washington.*
HICKS, HARLIE H., airplane engineering division, Signal Corps, U. S. A., *Dayton, Ohio.*
HOBBS, J. W., automobile expert, Ordnance Department, Rock Island Arsenal, *Rock Island, Ill.*
HOLDEN, F. M., airplane engineering division, Signal Corps, U. S. A., *Washington.*
HONIGMAN, JOS. K., instructor, U. S. School of Military Aeronautics, Princeton University, *Princeton, N. J.*
KING, CHARLES B., aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*
KISHLINE, FLOYD F., laboratory assistant, Quartermaster Corps, *Washington.*
KROEGER, F. C., Quartermaster Corps, U. S. A., *Washington,* assigned as engineer on electrical equipment.
KUEMPEL, REUBEN, U. S. N., Naval Air Station, *Pensacola, Fla.,* assigned to Bureau of Steam Engineering.
LADDON, I. M., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*
LANE, ABBOTT A., inspector, Aviation Section, Signal Corps, (mail) Room 52, 870 Woodward Avenue, *Detroit.*
LEOPOLD, JOS., Engineers' School, U. S. School of Military Aeronautics, Ohio State University, *Columbus, Ohio.*
LONGLETZ, WESLEY, Signal Corps, U. S. A., assigned as inspector on airplane engines at The Nordyke & Marmon Co., *Indianapolis.*
MCCAIN, GEO. L., Signal Corps, U. S. A., *Dayton, Ohio,* assigned to airplane engineering department, Engine Design Section.
MCMASTER, MARCENUS D., aeronautical engineer, Equipment Division, Signal Corps, *Washington.*
MENNEN, F. E., Quartermaster Corps, U. S. A., *Washington,* assigned to Transportation Division.
MILLAR, THOMAS H., JR., Quartermaster Corps, U. S. A., 205 Union Station, Washington, assigned to Motor Transportation Section.
MORGAN, G. W., supervisor of plant survey, Military Truck Production Section, Office of Quartermaster General, *Washington.*
NELSON, A. L., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*
NEUMANN, JOHN W., Planning Section, Machine Division, U. S. Navy Yard, *Philadelphia.*

O'MALLEY, JOHN M., instructor, Aviation School, Signal Corps, *Washington.*
OTIS, J. HAWLEY, Ordnance Department, U. S. A., Camp Dodge, *Des Moines, Iowa.*
PARISH, W. F., Signal Corps, U. S. A., *Washington*, assigned to Specification Section, Equipment Division.
PARKER, VICTOR C., Signal Corps, U. S. A., *Washington*, assigned to Equipment Division.
PARRIS, JR., EDWARD L., senior inspector, Aviation Section, Signal Corps, (mail) Ericsson Mfg. Co., *Buffalo.*
PERRIN, J. G., assistant, Signal Corps, U. S. A., 401 Lindsey Bldg., *Dayton, Ohio*, assigned to airplane engineering division.
POLLOCK, RAY C., Signal Corps, U. S. A., Buffalo, assigned as airplane engine inspector.
PROCTOR, C. D., Ordnance Department, U. S. A., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section, Carriage Division.
RICE, HARVEY M., inspector, Aviation Section, Signal Corps, (mail) Curtiss Aeroplane Co., *Buffalo.*
RIPPINGILLE, E. V., Aviation Section, Signal Corps, *Washington.*
ROGERS, JOHN M., aeronautical engineer, Bureau of Construction & Repair, Navy Department, *Washington.*
RUCKSTELL, G. E., Signal Corps, U. S. A., assigned as aeronautical mechanical engineer, *Detroit.*
SALISBURY, EDWARD V., chief of motor transportation, American International Corp., Government Shipbuilding Yard, Hog Island, *Philadelphia.*
SCHELL, JOHN A., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*
SCHUPP, ARTHUR A., aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*
SEABURY, W. M., Field Hospital, No. 337, Camp Custer, *Battle Creek, Mich.*
SEARLE, C. A., auto-parts inspector, U. S. A., *Washington.*
SERRELL, ERNEST, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*
SHILLINGER, G. P., Ground Officers' Engineering School, Kelly Field No. 1, *San Antonio, Tex.*, assigned as instructor in ignition, starting and lighting.
SLOANE, JNO. E., Signal Corps, U. S. A., *Washington*, assigned to Equipment Division.
SMITH, G. W., JR., aeronautical mechanical engineer in charge of experimental division, Engineering Department, Naval Aircraft Factory, U. S. Navy Yard, *Philadelphia.*
STALB, ARTHUR R., JR., U. S. Navy Aeronautic Station, *Pensacola, Fla.*, assigned as aeronautic draftsman, Hull Division.
STANTON, D. T., military instructor, U. S. Army School of Military Aeronautics, Cornell University, *Ithaca, N. Y.*
STOUT, WILLIAM B., technical adviser, International Aircraft Standards Board, *Washington.*
THIBAULT, F. J., aeronautical mechanical engineer, Signal Corps, U. S. A., *Washington.*
TONE, FRED I., inspector, Aviation Section, Signal Corps, *Washington.*
TRACY, PERCY WHEELER, supervisor of parts plants, Military Truck Production Section, Office of Quartermaster General, *Washington.*
UTZ, JOHN G., supervisor of inspection, Office of Military Truck Production Section, Office of Quartermaster General, *Washington.*
VAN LOON, HENRY M., 310th Engineers, Camp Custer, *Battle Creek, Mich.*
WADE, GUSTAV, inspector, Aviation Section, Signal Corps, *Dayton, Ohio.*
WALDRON, RUSSELL E., Signal Corps, U. S. A., *Detroit*, assigned to Equipment Division.
WALKER, KARL F., automotive engineer, Quartermaster Corps, U. S. A., *Washington*, assigned to Engineering Laboratory.
WALTER, JOHN M., mechanical draftsman, Bureau of Ordnance, Navy Department, *Washington.*
WARNER, EDWARD P., Signal Service at Large, U. S. A., *Washington*, assigned as aeronautical engineer.
WATERHOUSE, W. J., aeronautical engineer, Aviation Section, Signal Corps, (mail) Dayton-Wright Airplane Co., *Dayton, Ohio.*
WEISS, E. A., automobile designer, Quartermaster Corps, U. S. A., *Washington*, (mail) 812 C Street, S. E.
WHINNE, WILBUR H., inspector, Quartermaster Corps, U. S. A., *Detroit.*
WHITE, PERCIVAL, automobile expert, Ordnance Department, U. S. A., Rock Island Arsenal, *Rock Island, Ill.*
WILLIAMS, S. T., Naval Aircraft Factory, Navy Yard, *Philadelphia, Pa.*, assigned as aeronautical mechanical engineer in Engineering Department.
WINTER, E. A., War Department, Rock Island Arsenal, *Rock Island, Ill.*
WORTHEN, C. B., inspector, Aviation Section, Signal Corps, U. S. A., *Washington.*

Applications *for* Membership

A list of current applications for membership is given below. The members are urged to send any pertinent information with regard to those whose names are given which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

ALLEN, THEODORE T., western manager, Class Journal Co., *Chicago.*
ARNOLD, D. L., chief engineer, laboratories, International Harvester Corp., *Chicago.*
BARBAROU, MARIUS, general manager, Société Lorraine des Anciens Etablissements De Dietrich & Cie., Route de Bezons, *Argenteuil, France.*
BENJAMIN, DAVID, purch. agt., ass't. to off. & fact. mgr., Gabriel Mfg. Co., *Cleveland.*
BLAKELY, EDWARD BRADFORD, advisory mech. engr., Sears, Roebuck & Co., *Chicago.*
BROWN, CHARLES SEAMANS, assistant to chief of Automotive Products Section, War Industries Board, *Washington.*
BRUNNER, GEORGE L., treasurer, general manager, Brunner Mfg. Co., *Utica, N. Y.*
BULLOCK, WILLIAM EDWARD, associate editor, American Society of Mechanical Engineers, *New York.*
BUTZMAN, LESTER E., draftsman, Weger Aeronautical Motor Co., *Cleveland.*
CASS, LEE L., chief draftsman, Parrett Tractor Co., *Chicago Heights, Ill.*
CASSEL, ADAM F., material department, Chevrolet Motor Co., *New York.*
CLEMENTS, FRANK ORVILLE, director, Dayton Metal Products Co., Research Division, *Dayton, Ohio.*
CRITCHLOW, JOHN NISBET, inspection engineer, United Alloy Steel Corp., *Canton, Ohio.*
CROCKER, ELMER S., chief draftsman, Militor Corporation, *Jersey City, N. J.*
DAVIS, GORDON C., tool design checker, Nordyke & Marmon Co., *Indianapolis.*
DENKINGER, GEORGE MARSHALL, instructor, Signal Corps, Massachusetts Institute of Technology, *Cambridge, Mass.*
DRYSDALE, WILLIAM D., designing, Nordyke & Marmon Company, *Indianapolis.*
DUFFY, J. FRANK, efficiency engineer, Sumter Electrical Works, *Sumter, S. C.*
EDWARDS, HENRY H., vice-president, mechanical engineer, The Bantam Ball Bearing Co., *Bantam, Conn.*
EDWARDS, JAMES A., Hall-Scott Motor Car Co., *Dayton, Ohio.*
EVANS, RICHARD W. C., sales engineer, Ingersoll Milling Machine Co., *Rockford, Ill.*
FEAR, RALPH GORDON, designing engr., Glenn L. Martin Aircraft Co., *Cleveland.*
FRANKLIN, CHARLES BAYLY, engineer, Motors Division, Production and Engineering Branch, Office Quartermaster General, *Springfield, Mass.*
GARFIELD, ELLERY I., mechanical engineer, Renault Works, *Billancourt, Seine, France.*
HAHL, GEORGE EDWARD, sales engineer, Doehler Die Casting Co., *Brooklyn, N. Y.*
HELLMANN, LIN FREDERICK, supervisor of tool design, Nordyke & Marmon Co., *Indianapolis.*
HENZIE, FRANK D., general manager, Federal Pattern Works, *Indianapolis.*
HERRINGTON, ARTHUR W. S., consulting engineer, Engineering Department, Motorcycle Section, Quartermaster Corps, *Washington.*
HEYWOOD, CHARLES E., Publication Department, Society of Automotive Engineers, *New York.*
HILL, FRANK LEROY, JR., inspector, mechanical engineer, Hall-Scott Motor Car Co., *Berkeley, Cal.*
HINZ, JULIUS C., president, general manager, Bellevue Industrial Furnace Co., *Detroit.*
HOLLERITH, CHARLES, chief engine test inspector, Nordyke & Marmon Co., *Indianapolis.*
HUBBARD, BURT JARVIS, ch. engr., Apperson Bros., *Kokomo, Ind.*
HUETTICH, RUDOLPH C., superintendent, Brierley Machine Co., *Cleveland.*
JACOBS, ALONZO F., factory service representative, Splitdorf Electrical Co., *Kansas City, Mo.*
JOHNSON, FREDERICK H., insp. aeronautical material, U. S. N., *Buffalo.*
KERRINSH, EDWARD P., designer, The Winton Co., *Cleveland.*
KOLBE, ADELBERT E., layout man, Jordan Motor Car Co., *Cleveland.*
LAFOND, L. A., chief engineer, Tractor Department, Pan Motor Co., *St. Cloud, Minn.*
MAYER, HARRIS J., mechanical draftsman, Holt Manufacturing Co., *Peoria, Ill.*
MEREDITH, GEORGE WASHINGTON, engineer, Signal Corps, *Detroit.*
MORGAN, E. TASSO, senior inspector, Breese Aircraft Co., *Farmingdale, N. Y.*
MURPHY, WILLIAM T., gen. mgr., Standard Machinery Co., *Auburn, R. I.*
ORNELAS, ERNESTO, asst. processing engr., Bridgeport Brass Co., *Bridgeport, Conn.*
ORTLA, FREDERICK L., superintendent of garages, Metropolitan Coal Co., *Boston.*
PIERCE, CLARENCE A., chief engineer, Diamond T Motor Car Co., *Chicago.*
QUINN, WILLIAM J., assisting in laboratory work, Quartermaster Corps, Transportation Laboratory, *Washington.*
REES, JOHN HOWARD, general manager, Hawke & Co., *Kapunda, South Australia, Australia.*
RUSSELL, L. L., engineering department, Engineer and Motor Transportation Division, Squad Chief, Quartermaster Corps, *Washington.*
RYDER, SAMUEL E., sales engr., The Moto-Meter Co. Inc., *Long Island City, N. Y.*
SANDWICH, J. THOMAS, assistant manager, Tulsa Automobile Corp., *Tulsa, Okla.*
SMITH, JOSEPH ELDRIDGE, draftsman, Engineering Bureau, Motor Section, Ordnance Corps, *Washington.*
SMITH, PIERCE G., sales manager, American Malleable Co., *Lancaster, N. Y.*
SNOOK, WARD H., secretary, general manager, The Paulding Home Telephone Co., *Paulding, Ohio.*

SEDLEY, PARKE GODWIN, Chicago Branch Manager, Eisemann Magneto Co., 32 33rd St., *Brooklyn, N. Y.*

STEELMAN, B. J., vice-president, Hammond Malleable Iron Co., *Hammond, Ind.*

STEENSON, JAMES H., chief draftsman, Standard Aero Co., *Elizabeth, N. J.*

SUESZ, FERD. J., chief engineer, The Sayers & Scovill Co., *Cincinnati, Ohio.*

TINKLER, LOYAL G., chemical engineer, *Little Falls, N. Y.*

WHITACRE, WALTER, draftsman, Indiana Truck Corp., *Marion, Ind.*

WATT, GORDON J., squad foreman, Curtiss Aeroplane Co., *Buffalo.*

ZEIGLER, LESTER A., asst. gen. mgr., Zeigler Mfg. Co., *Alexandria, Ind.*

Applicants *Qualified*

The following list of applicants have qualified for admission to the Society between February 15 and March 13, 1918. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

ACTION, MICHAEL J. (Aff. Rep.) factory manager, Lapointe Machine Tool Co., *Hudson, Mass.*

ADAMS, C. A. (M) professor of engineering and consulting engineer, Massachusetts Institute of Technology, Harvard University, *Cambridge, Mass.*

ALLISON, L. M. (M) chief engineer, Lawson Aircraft Corporation, *Green Bay, Wis.*, (mail) P. O. Box 801.

ANDERSON, J. D. (M) factory manager, vice-president, The Fisk Rubber Co., *Chicopee Falls, Mass.*

BALL, RUSSELL C. (M) secretary-treasurer, Philadelphia Gear Works, 1120 Vine St., *Philadelphia, Pa.*, (mail) 5912 Ellsworth St.

BARNES, HAROLD H. (M) chief engineer, The Unit Power Wheel Co., Station B., Box 38, *Cleveland.*

BATES, STANLEY E. (M) chief engineer, vice-president, Lee Loader and Body Co., 2343 South LaSalle St., *Chicago*, (mail) 6555 Normal Ave.

BEACH, CHARLES S. (A) shop superintendent, Willys-Overland, Inc., 521 W. 57th St., *New York.*

BRUCE, VIVIAN R. (M) general manager, The Hilliard Clutch and Machinery Co., *Elmira, N. Y.*

BUDINGER, E. J. (J) auto spring designing, layout work, Standard Parts Co., 412 Hickox Bldg., *Cleveland.*

BOLGER, ROBERT S. (M) production engineer, International Motor Co., *New York*, (mail) 3303 Fulton St., Richmond Hill.

COLE, RAYMOND A. (J) engineer, Robert T. Pollock Co., 68 Devonshire St., *Boston.*

CHRISTENSEN, NEILA A. (M) president, The Christensen Engineering Co., *Milwaukee*, (mail) 816 First National Bank Bldg.

CHILDE, J. B. (A) vice-president, general manager, Cleveland Axle Mfg. Co.; The Cleveland-Canton Spring Co., 2027 Dueber Ave., S. W., *Canton, Ohio.*

DAVIDGE, A. V. (M) superintendent of design, Austin Motor Co., *Northfield, Birminghan, England*, (mail) "Rosebank," Steel Road.

DESAUTELS, CHARLES H. (M) special work, The Fisk Rubber Co., *Chicopee Falls, Mass.*, (mail) 106 Magazine St., *Springfield, Mass.*

ELY, HEMAN (M) secretary, The Timken Roller Bearing Co., *Canton, Ohio.*

FICK, FERDINAND E. (M) tool designer, The Nordyke & Marmon Co., *Indianapolis.*

FITZGERALD, GERALD (A) second lieutenant, Motor Truck Company 348, U. S. A., *Camp McArthur, Texas*, (mail) 3817 North Delaware St., *Indianapolis.*

FORSBLOOM, VICTOR I. (M) chief of technical department, Aksai Co., *Rostov-on-Don, Russia*, (mail) care of E. A. Murphy, 2680 Boulevard, *Jersey City, N. J.*

FOSTER, WILLIAM J. (A) second lieutenant, aeronautical mechanical engineer, Aviation Section, Signal Reserve Corps, *Washington*, (mail) 15 E. 38th St., *New York.*

GOFF, DOUGLAS C. (A) assistant sales manager, Winther Motor Truck Co., *Winthrop Harbor, Ill.*

GRAMM, B. A. (M) manager, The Gramm-Bernstein Motor Truck Co., *Lima, Ohio.*

HOFFMAN, THEODORE (A) general manager, director, Doues Amovibils, France, (mail) 39 rue Franklin, *Ivy-Port (Seine), France.*

HAMILTON, CHESTER B. JR. (M) mechanical engineer, proprietor, Hamilton Gear & Machine Co., 15 Van Horne St., *Toronto, Canada.*

JAMESON, WILLIAM (M) advisory engineer, The Fisk Rubber Co., *Chicopee Falls, Mass.*

KNISLEY, B. R. (A) superintendent, designer, Hawkeye Mfg. Co., *Sioux City, Iowa*, (mail) West Hotel.

KOPLE, M. (S.E.) student, Armour Institute of Technology, *Chicago*, (mail) 4310 Cottage Grove Ave.

KINGSBURY, JESSE A. (M) metallurgist, The Studebaker Corp. of America, *S. Bend, Ind.*, (mail) 152 Temple St., *New Haven, Conn.*

LEWIS, G. H. (M) supervisor of experimental department, The Fisk Rubber Co., *Chicopee Falls, Mass.*, (mail) 13 Victoria Park.

LORD, CHAS. E. (M) general patent attorney, International Harvester Co., 602 S. Michigan Avenue, *Chicago.*

MAYER, ARTHUR (A) production manager of bumper department, Edw. V. Hartford, Inc., 143 Morgan St., *Jersey City, N. J.*, (mail) Lefferts and Hillside Aves., *Richmond Hill, N. Y.*

MOHR, ALBERT F. (M) engineer, Hyatt Roller Bearing Co., 1120 Michigan Ave., *Chicago*, (mail) 4540 N. Central Park Ave.

MEISTER, H. O. K. (A) sales manager, Hyatt Roller Bearing Co., 1120 Michigan Avenue, *Chicago.*

MACBETH, COLIN (M) experimental engineer, Dunlop Rubber Co., Ltd., *Birmingham, England.*

MOFFITT, FRANCIS A. (M) partner, chemical engineer, B. O. Moffitt's Sons, 28-34 Collier St., *Binghamton, N. Y.*, (mail) 72 Hawley St.

NAYLOR, R. B. (M) chief chemist, The Fisk Rubber Co., *Chicopee Falls, Mass.*

PIERSON, T. A., JR. (S. E.) student, Massachusetts Institute of Technology, *Cambridge, Mass.*, (mail) 44 Magazine St.

PIGOTT, REGINALD J. S. (M) superintendent of raw materials, consulting engineer, Bridgeport Brass Co., Remington Arms; Sanford Riley Stoker Co., *Bridgeport, Conn.*, (mail) University Club.

ROUNDS, EDWARD W. (J) instructor in military aeronautics, U. S. N. R. F. C., U. S. Naval Aviation Detachment, *Cambridge, Mass.*

ROBERTS, E. W. (M) consulting internal combustion engineer, Editor *Gas Engine, Cincinnati, Ohio*, (mail) P. O. Box 580.

ROSS, OSCAR A. (M) consulting engineer, 154 W. 57th St., *New York.*

SCRIBNER, GEO. K. (M) chief engineer, Boonton Rubber Mfg. Co., *Boonton, N. J.*, (mail) Reserve St.

SAUNDERSON, H. S. (A) managing director, General Motors, Ltd., 136 Long Acre, *London, W. C., England*, (mail) Wellington Club, Grosvenor Place, *London, S. W., England.*

SIMPSON, HOWARD W. (J) inspector of aircraft engines, Inspection Section, Equipment Division, Signal Corps, U. S. A., Garfield Bldg., *Detroit*, (mail) 128 Clairmount Ave.

SCHALLER, H. W. (M) designing engineer, The Aultman-Taylor Machinery Co., *Mansfield, Ohio*, (mail) 99 Lexington Ave.

SHULER, FRANK A. (A) president, Shuler Axle Mfg. Co., *Detroit.*

SINK, RUSSELL S. (S. E.) student, Purdue University, *Lafayette, Ind.*

SCHELL, ROBERT C. (M) superintendent, Crow-Elkhart Motor Co., *Elkhart, Ind.*, (mail) 422 E. Beardsley Ave.

STEHLE, FRANK K. (A) treasurer, Bearings Company of Pa., 684 North Broad St., *Philadelphia.*

SCHROETER, JR., BRUNO (M) checker, Hupp Motor Car Corp., *Detroit*, (mail) 397 Helen Ave.

SPURGEON, K. A. (A) general manager, Muncie Gear Works, N. Vice Street, *Muncie, Ind.*

SCHIRMER, J. O. (M) president, The Schirmer Co., Inc., Cleveland, sales and consulting engineer, The Peters Machine & Mfg. Co., *Cleveland*; The Vikin Pump Co., *Cedar Falls, Iowa*, (mail) care of The Schirmer Co. Inc., 7319 W. Madison Ave.

SINDELAR, EDWARD F. (S. E.) salesman, Beckley Ralston Co., 1801 S. Michigan Ave., *Chicago*, (mail) 1626 S. Central Park Ave.

TAYLOR, EDGAR E. (S. E.) student, Lewis Institute, Madison & Roby Streets, *Chicago*, (mail) 9 North Bishop St.

TARKINGTON, J. ARTHUR (M) general superintendent, consulting engineer, The Kissel Motor Car Co., *Hartford, Wis.*, (mail) 270 E. Sumner St.

TEW, JAMES D. (M) assistant superintendent, The B. F. Goodrich Co., *Akron, Ohio.*

TUBBS, GEORGE E. (M) secretary, works manager, Alamo Farm Light Co., Box 273, *Hillsdale, Mich.*, (mail) 56 S. Broad St.

TAYLOR, CHARLES W. (S. E.) student, University of Cincinnati, *Cincinnati, Ohio*, (mail) 3491 Harvey Ave.

WADSWORTH, H. L. (M) manager, The Sand Mixing Machine Co., 111 Power Ave., *Cleveland.*

WHYTE, JOHN, (M) chief engineer, Bailey Non-Stall Differential Corp., 1124 Michigan Ave., *Chicago*, (mail) 5438 Cornell Ave.

WATERHOUSE, H. D., (A) chief engineer, Bay State Pump Co., 100 Purchase St., *Boston.*

WEIDLING, C. J. (M) chief engineer, Oneida Motor Truck Co., 1800 S. Broadway, *Green Bay, Wis.*

WOODS, E. L. (Aff. Rep.) J. I. Case Plow Works, *Racine, Wis.*

WILEY, C. O. (M) northwestern representative, Kokomo Electric Co., Byrne, Kingston Co., *Kokomo, Ind.*, (mail) 1002 W. Taylor St.

WARE, JOHN PUTNAM (A) sales engineer, Clark Equipment Co., *Buchanan, Mich.*

WONG, S. T. (S. E.) student, Massachusetts Institute of Technology, *Cambridge, Mass.*, (mail) 34 Williams St.

ZWINGLE, CARL T. (S. E.) student, Stevens Institute of Technology, *Hoboken*, N. J., (mail) 345 Graham Ave., Paterson, N. J.

Book Reviews *for* S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described as soon as possible after their receipt, the purpose being to show the general nature of their contents and to give an estimate of their value.

AVIATION ENGINES: By Lieut. Victor W. Pagé, A.S., S.C., U.S.R. Published 1918 by The Norman W. Henley Publishing Co., 2 West 45th Street, New York. 6 by 9 in., 590 pages, 253 ill. Price $3.

"Aviation Engines," one of the latest books by Victor W. Pagé, was prepared primarily for instruction purposes, having been adapted for men in the Aviation Section of the Signal Corps and for students who wish to become aviators or mechanicians. In general the book covers the design, construction and repair of airplane engines, which necessitates the use of many illustrations. It was necessary to submit the book for censorship, as many of the illustrations used were of engines now in use or in production. However, the absence of several of the illustrations does not interfere in any marked degree with the continuity of the text.

The author states that every effort has been made to have the engineering information accurate, but that owing to the diversity of the authorities consulted and the use of data translated from foreign periodicals, it is to be expected that errors will be present. Many of the illustrations used were obtained from different airplane firms in this country, as was also much of the descriptive matter.

Special attention has been given to the use of tools, trouble "shooting" and engine repairs, as the author has experienced that the average aviation student is weakest on these points.

The first three chapters have been devoted to the theoretical consideration of the thermodynamics of the gas engine, as the author deemed it advisable to give each student a proper understanding of engine action. However, most emphasis is placed on a practical series of instructions for those who need a diversified knowledge of internal combustion engine repair and operation, and who must acquire it quickly.

One chapter is devoted to the superiorities of the multicylinder engine, photographs being reproduced of engines representing the different cylinder arrangements possible.

Other chapters are devoted to carburetion, ignition, oiling and cooling systems, valve mechanisms and piston, connecting-rod and crankshaft design. Descriptions of the more important carbureters, magnetos, and oiling and cooling systems have been incorporated in these chapters. The different methods of installing power plants are covered in full, illustrations of the Curtiss OX2 and the Hall-Scott engines having been included.

Several tables have been prepared by the author on "Trouble Shooting." Engine troubles have been classified as: Lost power and overheating, noisy operation of power plant, and irregular operation. Under these headings are four columns headed: Parts affected, nature of trouble, symptoms and effects, and the remedy. Ignition and carburetion trouble have been dealt with at length under separate heads.

The chapters on repair and maintenance of airplane engines are very complete and should be a great help for prospective airplane mechanicians. A large number of descriptions of airplane engines have been given which are of general interest, but contain little information which has not already been published in some form.

D'ORCY'S AIRSHIP MANUAL. By Ladislas D'Orcy. Published, 1917, by the Century Company, 353 Fourth Ave., New York. Cloth, 10 by 7-in., 232 pages, 190 ill. Price, $4.

The author states that the present volume is the result of a methodical investigation extending over a period of four years, in the course of which many hundreds of English, French, Italian, German and Spanish publications and periodicals dealing with the present status, as well as with the early history of airships, have carefully been consulted and digested. It has thus become possible to gather under the cover of a handy reference book a large amount of hitherto widely scattered information, which, having mostly been published in foreign languages, was not immediately available to the English-speaking public.

The information thus gathered is presented in two parts; one being a compendium of the elementary principles underlying the construction and operation of airships, the other constituting an exhaustive but tersely worded register of the world's airships, which furnishes complete data, when available, for every airship of 500 cubic meters and over, that has been laid down since 1834. Smaller airships are listed only if they embody unusual features.

It has been attempted to furnish here the most up-to-date information regarding the gigantic fleet of airships built by Germany since the beginning of the Great War, a feature which may, in a certain measure, repay the reader for the utter lack of data on the Allies' recent airship constructions, which had to be withheld for military reasons.

In view of the recent rapid development of the airplane compared with the airship, the author has deemed it fit to consider the future of the latter. "Without going into a detailed discussion of these plans, one might remark that whereas the safety of the passengers is quite an interesting item in public transportation, the airship appears, in the main, to fulfill this condition to a far greater degree than the airplane, since the airship is capable of staying aloft regardless of engine failure, a thing the airplane cannot, and probably will not, do for some time to come. This feature, which enables the airship to outride a storm if a landing proves impracticable, should eventually prove a valuable asset for oversea voyages, where the matter of alighting on the sea during a storm appears all but a pleasant prospect. And it should be remembered that the development of the airship has by no means kept pace with that of the airplane, this being mainly due to the important expenditure involved in the construction of airships.

AVIATION CHART. By Lieut. Victor W. Pagé. A.S., S.C., U.S.R. Published, 1918, by the Norman W. Henley Publishing Co., 2 West 45th St., New York. Paper, 4 by 5 ft., 12 tables, 5 ill. Price, 50 cents.

This chart has been prepared to outline in a simple manner the various troubles and derangements that interfere with efficient internal combustion engine action. The

(Concluded on page 52, Advertising Section)